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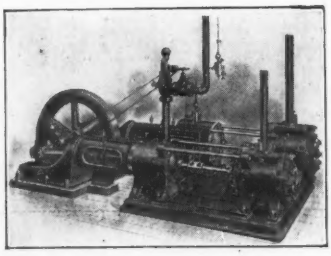
Vol. XII JUNE 1907 No. 4



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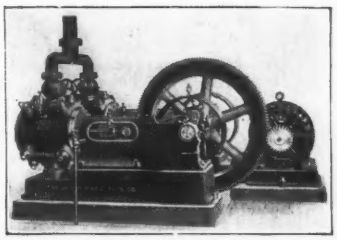

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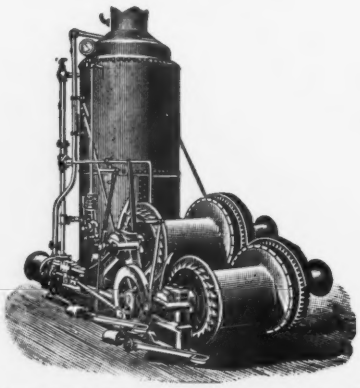

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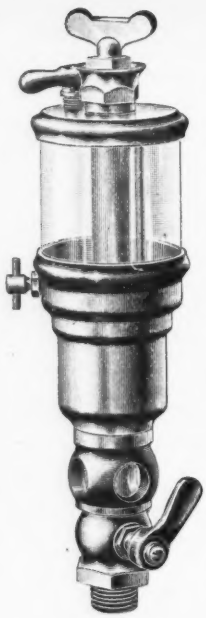

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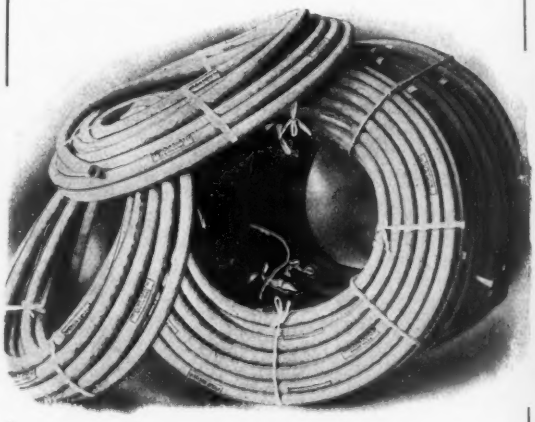

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THE COMPRESSED AIR BAR

By A. C. Musehold, St. Louis, Mo.

The Pressluftstabzuführungs-Gesellschaft m. b. H. of Berlin, Germany, has filed patents at Washington for an invention that has met with striking success on the European Continent. The object of this invention is the compressed air bar, which is chiefly used for:

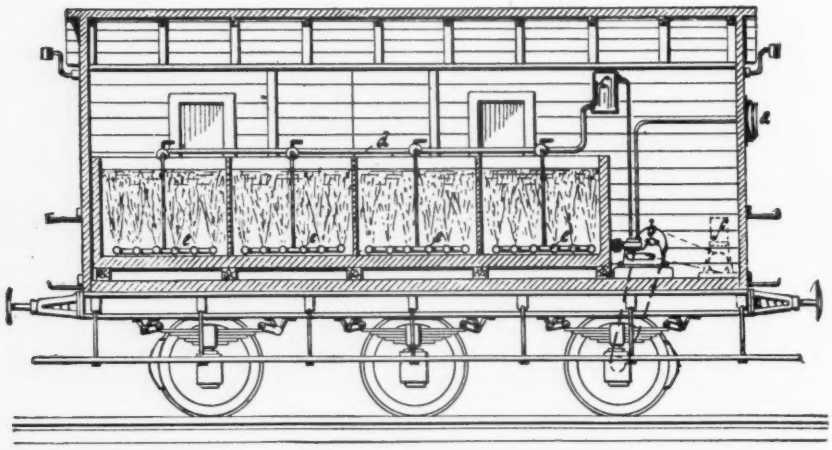
1. Keeping fish alive during transports over long distances, be it by special fish railroad cars, ocean or lake and river steamers, or storage of live fish and other gill-breathers in tanks, aquariums, terrariums, etc.
2. Eliminating iron from water ("des-ironing") for drinking water, and water used for industrial purposes, such as breweries, paper manufactories, dye works, laundries, etc.
3. Medical baths ("pearl air baths").
4. Charging and mixing intimately gases with liquids of any kind.

In a bar-like body compressed air is stored up and led off to that liquid, upon which it is intended to have effect. This bar, which is connected to a system of pipes, is fed by means of a pump with air or gas of any desired density, being controlled in such a manner that the air or the gas flows out under a pressure adapted to the purpose wanted, and running through the liquid from down below up to the surface. In order to attain a perfect aeration of the water or other liquid, the compressed air bars must be placed at the bottom of the tank, and the air in the bar must be under a pressure that is greater than the pressure of the liquid that is above them. Since the pressure exerted by a column of water of 10 meters height is but 1 atmosphere, it is evident that it is only a small amount of density-pressure which is required in practice.

The importance of this invention was suggested by the fish merchants, Jacob Bros., of Berlin, who were aiming at keeping fish alive for long periods of time, such as during long journeys on the railroads and in stationary tanks. The process hitherto used for this purpose was that fresh water was forced under sufficient pressure into the tanks, to form a jet. Although air is carried away by the jet of water, it is plain that the greater the quantity of water in the tank, the less aeration there is proportionately.

Experience, however, has taught that in order to keep fish alive the renewing of the water is less important than a continuous thorough aerating of the water used. This aerating is the more necessary the greater the quantity of fish is in proportion to that of the water in which they are to live.

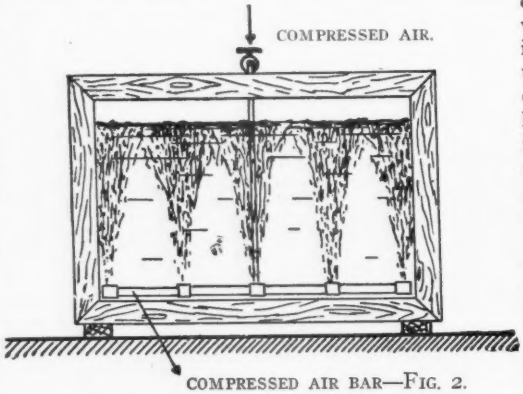
These were the points of consideration, the result of which is the following arrangement for transportation of live fish by special fish railroad cars, as shown by Fig. 1. Through filter "a" air is sucked by the air pump "b" and



SPECIAL FISH-RAILWAY CAR—FIG. 1.

forced into the branch pipes connected with them, to the compressed air bars at the bottom of the fish tanks. From these bars, very fine streams of fresh air flow into the water and mount up to the surface (Fig. 2). The strength and quantity of air supplied to each tank can be perfectly controlled by cocks and valves in the pipe-lines.

The air-pump can be operated either by belting from the axle of the car or by a little motor "f." Although the first way of operation is less expensive, it is dependent upon the movement of the car. Therefore, in order not to stop the supply of air when the car stops for any length of time, the motor will be indispensable, and it will be the only means for stationary tanks.



COMPRESSED AIR BAR—FIG. 2.

According to the experience of the Berlin fish merchants, Jacob Bros., the tanks provided with the compressed air bar system, can not only be filled with a considerably greater quantity of fish than formerly, but the duration of transportation can be greatly increased. Live fish have been transported repeatedly on the way for eighty-two hours with the greatest success. In such cases, cars of 75 per cent. load require but 25 per cent. water.

The adaptability of the compressed air device for thoroughly aerating water, on account of its striking simplicity, made it possible to use this system, for eliminating iron from water. Also in this country the subsoil and spring-water contain so much dissolved iron that it must be eliminated, in order to be used for the municipal supply and for technical establishments, such as dye works, laundries, paper mills, breweries, etc. The process hitherto used for this purpose consisted usually of a supply of air, the oxygen of which transforms the iron that is found in the water in the shape of protoxide salts, to hydroxide, which is indissolvable in water and can therefore be separated from it by mechanical means.

The ways and means of filtering are, however, of great variety. In most cases the water is forced through sprays (shower devices), in order to aerate it on gravel heaps; or, the water ripples through coke, etc. In order to insure sufficient aerating of the water, such plants must be often of considerable height, and, naturally, the lifting of the water requires correspondingly powerful pump works. This is not necessary when plate filters made of artificial sandstone are used; such an arrangement will, however, be more complicated.

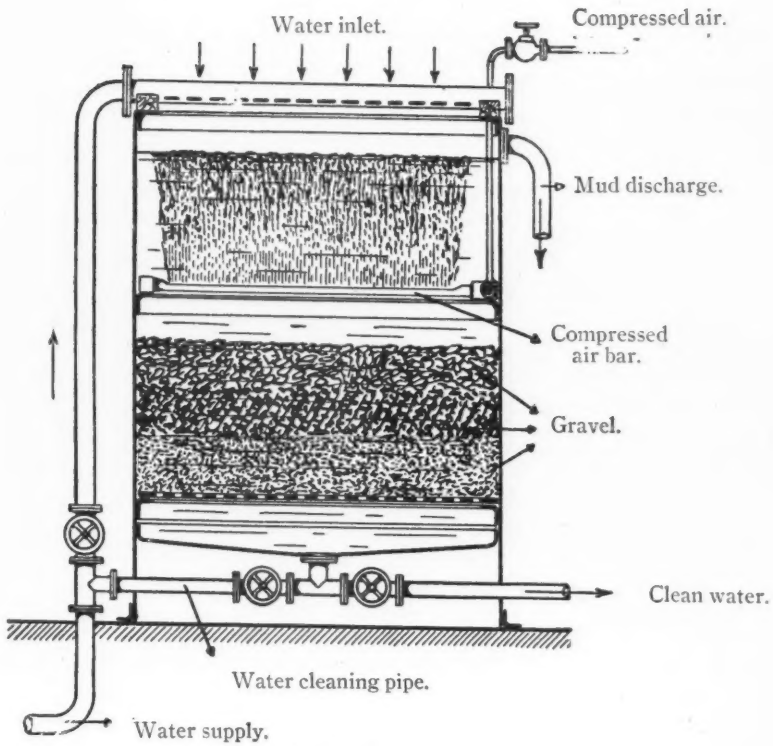
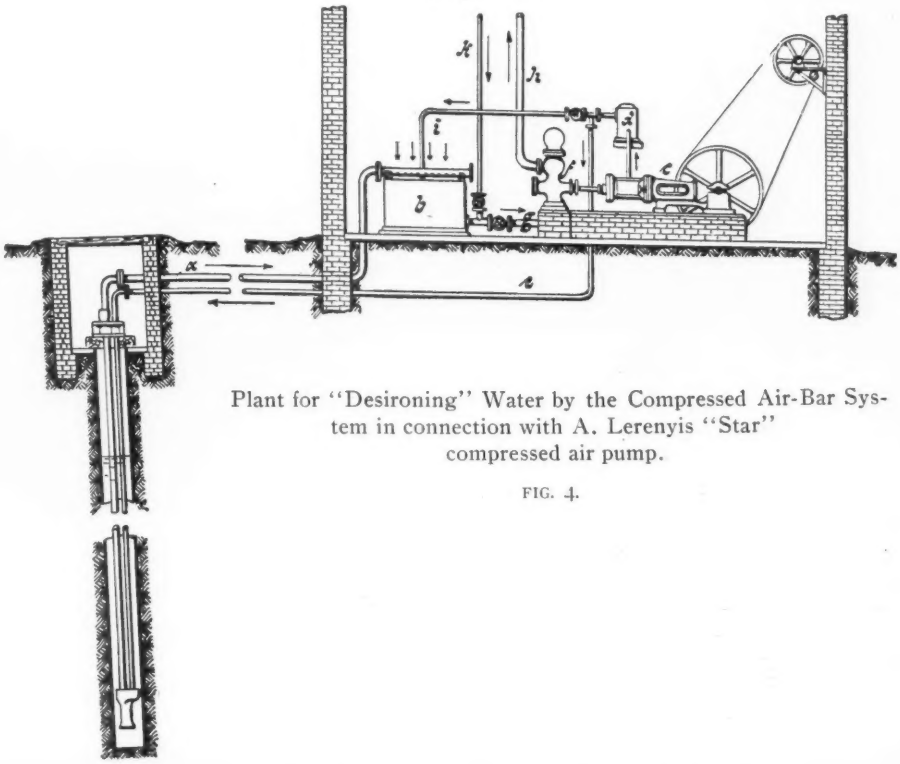


FIG. 3.



Plant for "Desironing" Water by the Compressed Air-Bar System in connection with A. Lerenyis "Star" compressed air pump.

FIG. 4.

Essentially more simple is the installation of a compressed air bar "des-ironer" the general arrangement of which is shown in Fig. 3. For an intimate aeration of the water we need but a comparatively small quantity of air at low pressure, for which reason only a comparatively little power is necessary to operate the whole plant, which can be very much smaller for an equal quantity of water than all other plants for "des-ironing" water.

A "des-ironing" plant in connection with a compressed air pump is shown in Fig. 4. Through pipes "a" the water lifted by means of compressed air pump "c" to the "des-ironer" "b," which is provided with a compressed air bar filled up with compressed air, through piping "i" from the air receiver "d," which is fed by the air pump. The "des-ironed" water is taken through piping "g" by means of forcing pump "f" from the "des-ironer," and pressed through piping "h" into the high-level service tank for used water. The cleaning of the "des-ironer" is done in the usual way by return water, by means of pipe "k."

Also for medical purposes the compressed air bar gives excellent results, i. e., for oxygen-pearl-air baths. The compressed air bar can be installed for any bath tub; the only outfit necessary is a tank of compressed air with reducing value, about 7 ft. of high pressure hose and the compressed air bar, which fits any bath tub. Medical authorities consider it especially good for reducing flesh.

One tank of compressed air is sufficient for about forty baths, depending on the time of each bath, and costs but a few cents.

The simplicity of the arrangement of the compressed air bar in industrial establishments would make it desirable, and it should prove as useful in the special fish cars and storage tanks of this country, as it is in those plants now in operation in Europe.

PREVENTION OF ACCIDENTS TO WORKMEN.

By CHARLES M. RIPLEY.

One of the hazardous undertakings made necessary by demands of commercial and financial interests to-day, is the digging of deep foundations for skyscrapers. Wherever there is considerable water encountered underneath the surface of the ground, as is the case on Manhattan Island south of about Fulton street, it has been almost universal practice of late years to employ the Pneumatic Caisson Process where the buildings are to be of twenty stories or more. This process greatly resembles the tunnelling work now being done under the Hudson River for the terminals of some of the railroads centering in New York. These caissons are, however, carried down vertically to bed rock, instead of horizontally across the bottom of the river; in both cases, however, compressed air is employed to prevent the water running in and flooding the working chamber—a catastrophe, the results of which need no comment.

This particular daring work is done in the face of peculiar and unexpected accidents, which only experience has taught to the contractors, and which only care and proper surveillance can be relied upon to prevent.

The unexpected character of these accidents is well illustrated by recalling the loss of perhaps a score of workmen's lives a few years ago in the old tunnel, now known as the McAdoo tunnel. Of all unexpected occurrences, down under the river, with the tons of water above them, only partially kept out by the compressed air employed for that particular purpose, perhaps the most unlooked for holocaust was *fire*. This experience which was due first to carelessness in enforcement of rules and was most destructive owing to the excess of oxygen in the air—one of the greatest possible stimulant to a conflagration. Mr. C. L. Brown, general superintendent of The Foundation Co., 35 Nassau street, New York, spoke at some length on this subject and stated that his company had for this particular reason installed electric lighting systems within the caissons while constructing the foundations for the twin Trinity buildings, the U. S. Express building, and the Singer building. The interior of a caisson of the regular type employed by this company contains electric lights, and the air whistle for signalling to men outside of the caisson or working chamber during regular cycle of work or in an emergency.

Where men, ascending from or descending to work, struck by the descending buckets or possible falling material dislodged above, this company adopted the most thorough protection by providing separate passageways for men and for materials. The right hand portion has a ladder for men and the left is used for the raising and lowering of buckets and material only. The ladders were put on that side of the shaft farthest away from material and

passing buckets. This preserves the workmen's hands from any possibility of being crushed.

Carrying out this same idea of separating men from the hoisting shaft, the foundation company have designed some of their air locks with a separate exit for men, operating independently of that for materials. Five of the caissons sunk for the Singer building foundations were topped with this style of air lock.

The admirable simplicity of this air lock is such that never have the doors become bound fast—a circumstance which has been known to imprison the workmen within the high pressure zone below. Another feature of this air lock which adds to the safety of the men is the fact that the bucket can be lifted to the open air in one continuous haul. This is the basis of the patent taken out by Mr. Daniel E. Moran, C. E., New York. The direct bearing of this feature is that were the material first hoisted to one level by one cable, and then hoisted from there to the open air by another cable, the act of transferring the bucket from one hoisting apparatus to the other is hazardous to every workman below.

There are two separate pipes employed to supply the men with requisite air pressure. In case one were to fail, the gauge tender would instantly detect the changes in the pressure and switch over to the other tube. The gauge tender is to the sand hog in the caisson about what the man at the air pump is to the deep sea diver—if the pressure were reduced, water would flow in and drown the men, while if the pressure were to grow too great, considerable suffering from the bends would result beyond doubt.

In addition to this paralleling of the air pipes, all the steam pipes are installed in duplicate also. This makes almost impossible a sudden cutting off of air supply. The company also has in reserve constantly an additional air compressor to act if an emergency should arise where their men's lives were at stake.

It is oftimes necessary in sinking these caissons to bed rock to add several tons of additional weight on the top. This was done in the past by employing workmen to carry pig iron by hand and pile it up in place. Through their own carelessness entirely it was found this method involved considerable peril to the workmen, and the company then designed a two-ton cast iron weight. A special shackle is cast into the weight for the purpose of rapid and safe handling by machinery. Since these were adopted, not a single injury has resulted from their use.

Upon leaving a job this contractor trucks the derricks, engines and all apparatus to the yards at Greenpoint, Long Island, where worn parts are replaced by new parts, and after a thorough inspection and coat of paint, stored ready for a new contract.

It is interesting to note that the painstaking efforts of this company to prevent accidents to their employes have not only been successful but have frequently proved an agreeable surprise as valuable time savers. This balance is on the credit side of the books, both from a humanitarian and a financial standpoint.

COMPRESSED AIR INEXPENSIVE.

The majority of people are of the opinion that to compress air or to employ it at industrial plants is very expensive. This is a mistake, for it can be compressed at low pressure very economically, although its field for operation is limited, and it is only at high pressures that it is expensive.

According to some authentic data recently received, "it takes 114 horse-power to compress 770 cubic feet of free air per minute to 60 pounds pressure per square inch, while 128 horse-power will compress 1,850 cubic feet of free air per minute to 20 pounds of pressure; therefore, at a cost of but 14 horse-power additional, 1,080 *more* cubic feet of free air can be compressed to 20 pounds than to 60 pounds, clearly proving the economy of using a low pressure. The horse-power developed to compress 100 cubic feet free air from atmosphere to 60 pounds is 13.41, and to 20 pounds, 6.28. This is a saving in favor of the lower pressure of 7.13 horse-power, or 53 per cent.

"In compressing air to a high pressure, great heat is generated. This means loss of power, for it takes power to make heat—*and power costs money*—it also necessitates the building of heavy water-jacketed compressors to withstand the high pressure and reduce the heat. On the other hand, in compressing air to a low pressure very little heat is generated; the compressor can be built of comparatively light material and with no water jacket if desired."

Interest has been aroused at Naples by a motor invented by Giovanni Dileo, a resident of Andria, twenty-two years old. The motor is operated by compressed air, and the inventor says that he has solved the principle of perpetual motion.

THE FLOW OF AIR IN LONG TUBES WITH SPECIAL REFERENCE TO PNEUMATIC DISPATCH.

Cy B. C. Batcheller.

PART III.

THE CO-EFFICIENT OF FRICTION.

FORMULÆ FOR COMPUTING *f*.

The value of the co-efficient of friction **f** may be determined experimentally by measuring the air pressure at two points of known distance apart in a tube through which a constant current of air is flowing, and at the same time determining the quantity of air flowing per unit of time or the mean velocity of the air or the time of transit of a particle of air between the two points at which the pressure is measured. The temperature of the air should also be noted. From this data the co-efficient can be computed by substituting in the formulæ of Part I.

by transforming equation (16)—

$$f = 962.6 \frac{t^2 d\ (461 + r)}{L^3} \frac{(p_1^2 - p_2^2)^3}{(p_1^3 - p_2^3)^2}$$

an equation in which the values of the pressures, time and temperature can be directly substituted.

If the initial velocity of the air can be measured, then *f* can be computed by transforming equation (13) thus:

$$f = 427.8 \frac{d\ (461 + r)\ (p_1^2 - p_2^2)}{u_1^2 L \qquad p_1^2}$$

Since *f* is a factor in nearly all our formulæ, it is important that its value should be determined experimentally under all possible conditions to ascertain if it is constant or variable, and if variable what its relations are to other factors of the formulæ.

Prof. Urwin has pointed out that *f* varies with the diameter of the tube, and he cites numerous experiments to prove such a relation. He has suggested an empirical formula, to express the relation between *f* and d, which fits the experiments thus far made very well. It is this:

$$f = 0.0027 \left(1 + \frac{3}{10\ d}\right)$$

in which d is the diameter of the tube in feet.

This formula is shown graphically by a curve, Fig. 13.

The suggestion has also been made that *f* varies somewhat with the velocity of the air, and my own experiments seem to indicate this to be a fact, but sufficient experiments have not been made to speak positively on this point.

First Philadelphia Experiments 6⅛-Inch Tube.

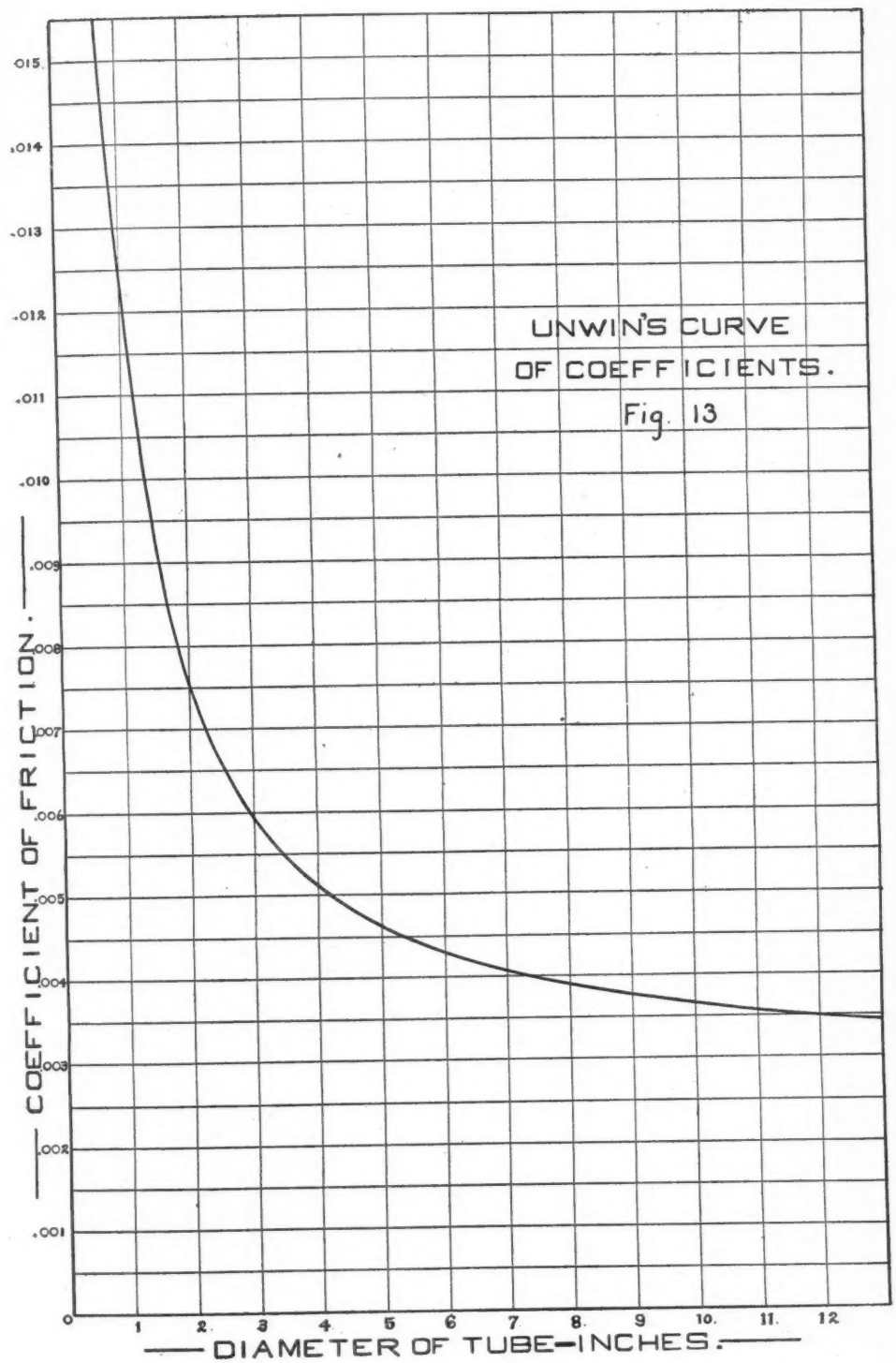
My first experiments were made in Philadelphia October 24, 1896, with the 6⅛-in. postal tubes that extend from the general post office to the branch post office in the Bourse. The time of transit of a light aluminum carrier between the two offices was carefully measured. The carrier had a cup leather packing attached to the rear bearing ring, to prevent the escape of air past it while it moved through the tube. The resistance of the carrier affected the initial pressure only 4/10 of 1 per cent. The air pressure in the tube was measured at the post office and at the Bourse with mercury manometers that could be read to 1/100 of an inch. The arrival and departure of the carrier at the Bourse was signaled at the post office by means of an electric circuit and a bell. The time of transit of the carrier was noted with a stop watch which could be read to quarters of a second. Unfortunately the temperatures of the air were not taken in these early experiments, but probably the error in estimating it was not large.

The straight part of the tubes are of cast iron, bored smooth on the interior. The bends, of which there are seven in each tube, are seamless brass.

The following tables give the results of these experiments.

East-bound tube L.....2992 ft.
East-bound tube.....L = 2992 ft.
Diameter of the tube.....0.5104

Number of Experiments	Pressure at Post Office. Inches of Mercury.	Pressure at Bourse. Inches of Mercury.	Time of Transit. Seconds.	f Computed by Formula (35)
1	10.60	5.83	64.	0.00433
2	10.56	5.76	63.5	0 00431
3	10.60	5.76	63.	0.00426
4	10.77	5.84	63.	0.00433
5	11.02	5.97	62.25	0.00431
6	10.94	6.02	62.25	0.00420
			Mean	.....0.00429


UNWIN'S CURVE
OF COEFFICIENTS.
Fig. 13
.015
.014
.013
.012
.011
.010
.009
.008
.007
.006
.005
.004
.003
.002
.001
0
1
2
3
4
5
6
7
8
9
10
11
12
COEFFICIENT OF FRICTION.
DIAMETER OF TUBE—INCHES.

WEST BOUND TUBE. L=2978 feet.

1	0.88	5.69	59.	0.00432
2	0.86	5.60	60.	0.00441
3	0.88	5.57	59.	0.00422
4	0.88	5.67	59.	0.00430
5	0.97	5.80	57.25	0.00411
6	0.91	5.82	57.75	0.00422
			Mean	0.00426

NOTE.—The pressures are given in inches of mercury above the atmosphere,

Prof. Urwin's formula gives for a tube 0.5104 ft. diameter:

$$f = 0.0027\left(1+\frac{3}{10\times .5104}\right)$$

Second Philadelphia Experiments, 6⅛-In. Tube

Five years later, June 28, 1901, I made another series of experiments, using this same tube, with carrier velocities that varied from about 20 to nearly 70 ft. per second. The method of conducting these experiments was substantially the same as in October, 1896. Special pains were taken to secure results of a high degree of precision. Manometers were constructed with means for dampening the oscillations, thereby increasing the accuracy of the readings. Corrections were made for the displacement of the zero and for the depression of the mercury in the reservoir. Barometer readings were taken frequently, which added to the corrected manometer readings, gave the absolute pressures. Pressure readings were observed every fifteen seconds during the transit of the carrier and the mean taken to compute results. Very low pressures were measured with a water instead of a mercury column. The time of transit observations were corrected for any error in the rate of the watch. In most of the experiments two independent observers noted the time of transit with stop watches. The temperature of the air in the tube was measured with thermometers in the stations and in a vault under the street. The portion of the tubes under ground were assumed to have the temperature indicated by the thermometer in the vault, and the portion in the stations a temperature that rose gradually from the temperature of the ground to the temperature indicated by the thermometers at the stations. On this basis a mean temperature was computed. A light aluminum carrier was used, with an elastic rubber packing attached to one of the bearing rings, that pressed air tight against the surface of the tube. A piece of thin sheet rubber was found to make a much more effective packing than leather, because of its greater elasticity and its tendency to cling to the surface of the tube. It increased the friction of the carrier somewhat, but it made certain that no air escaped past the carrier. A section of the packing is shown in Fig. 14. The speed of the air compressors was changed to vary the velocity of the air, and the experiments were arranged in groups, the velocity being approximately constant in each group.

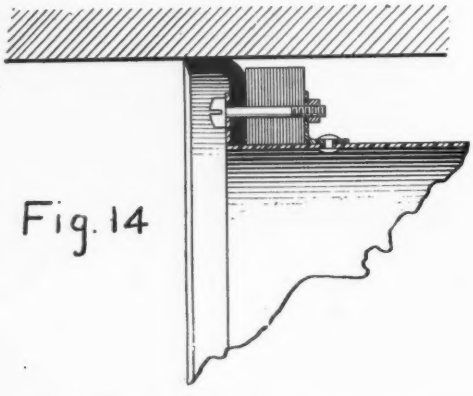


Fig. 14

The air compressor was located in the post office, and the air, which was above the atmospheric pressure in all parts of the tube, flowed from the post office to the Bourse in one tube and returned in the other, the return end being open to the atmosphere at the post office.

The following tables are a summary of the results:

EAST BOUND TUBE—JUNE 28th, 1901.
L=2992 feet. d=0.5104 feet.

Number of Experiment.	Mean Initial Absolute Pressure. Inches of Mercury, p_1	Mean Final Absolute Pressure. Inches of Mercury, p_2	Time of Transit. Seconds, t	Absolute Temperature, Fahrenheit. T	Coefficient of Friction, f Computed by Formula (35)	Mean Carrier Velocity feet per Second, Um
1	35.386	32.852	88.38	538.	0.005084	33.85
3	35.547	32 661	81.86	538.	0.004969	36 55
5	35.531	32.666	81.23	538 5	0.004862	36.83
7	35.421	32.604	82.61	538.5	0.004958	36.22
9*	39.698	38.443	144.61	538.5	0.005897	20.69
11	38.830	34.668	67.79	539.	0.004565	44.14
13	38.738	34.604	67.79	539.	0.004544	44.14
15	39.068	34.799	67.79	539.	0.004658	44.14
17	39 249	34.860	67.79	539.	0.004633	44.80
19	39.082	34.798	67.79	539.5	0.004678	44.14
21	43.219	36.800	56.74	539.5	0.004524	52.73
23	43.432	37.270	56.24	540.	0.004237	53.20
25	43.443	37.310	56.49	540.	0.004252	52.97
27	43.458	37.282	56.49	540.	0.004282	52.97
29	43.434	37.288	56.62	540.	0.004282	52.84
31	47.702	39.718	51.10	540.5	0.004180	58.55
33	47.178	39.410	50.97	541.	0.004091	58.70
35	47.267	39.471	51.10	541.	0.004098	58.55
37	47.163	39.352	51.35	541.	0.004178	58.27

*Valve in outlet of West Bound Tube partly closed.

WEST BOUND TUBE—JUNE 28th, 1901.
L=2978 feet. d=0.5104 feet.

Number of Experiment.	Mean Initial Absolute Pressure. Inches of Mercury, p_1	Mean Final Absolute Pressure. Inches of Mercury, p_2	Time of Transit. Seconds. t	Absolute Temperature. Fahrenheit. T	Coefficient of Friction. f Computed by Formula (35)	Mean Carrier Velocity feet per Second. Um
2	32.661	29.958	79.09	536.5	0.004785	37.65
4	32.685	29.959	78.22	536.5	0.004611	38.07
6	32.652	29.961	78.84	536.5	0.004734	37.77
8	32.606	29.962	79.59	536.5	0.004744	37.42
10	——	Lost.	——	——	Lost.	——
12	34.471	30.430	63.41	536.5	0.004431	46.96
14	34.501	30.437	63.53	536.5	0.004470	46.88
16	34.653	30.456	62.27	536.5	0.004423	47.82
18	34.660	30.472	61.77	536.5	0.004342	48.21
20	34.639	30 462	62.65	536.5	0.004456	47.53
22	36.904	30.792	50.72	536.5	0.004099	58.71
24	36.898	30.788	50.72	536.5	0 004098	58.71
26	36.882	30 784	50.60	536.5	0.004072	58.85
28	36.884	30.784	50.72	536.5	0.004093	58.71
30	36.889	30.781	50.85	536.5	0 004119	58.56
32	38.551	31.018	45.45	536.5	0.003938	65.52
34	38.954	31.096	44.57	536.5	0.003921	66.82
36	38.821	31.096	44.44	536.5	0.003841	67.01
38	38.905	31.084	44.94	536.5	0.003972	6627.

In order to compare the co-efficients with the velocity of the air, the mean velocity of the carrier is given in the last column.

The two following tables give the results of fourteen experiments:

EAST BOUND TUBE—MAY 5, 1901.
L=3882 feet. d=0.6778 feet.

Number of Experiment.	Mean Initial Absolute Pressure. Inches of Mercury. P_1	Mean Final Absolute Pressure. Inches of Mercury. P_2	Time of Transit. Seconds. t	Absolute Temperature. Fahrenheit. T	Coefficient of Friction. f Computed by (35)	Mean Carrier Velocity, Um
1	40.540	35.405	75.33	523.	0.003967	51.533
2	40.591	35.345	69.05*	523.	0.003374	56.220
3	40.575	35.449	75.58	523.	0.003982	51.363
4	40.581	35.447	75.20	523.	0.003948	51.622
5	40.541	35.416	75.58	523.	0.003985	51.363
6	40.552	35.405	75.33	523.	0.003977	51.533
7	40.570	35.417	75.33	523.	0.003979	51.533
8	40.563	35.419	75.33	523.	0.003972	51.533
				Mean (Omitting 2)..0.003973		

WEST BOUND TUBE.
L=3884 feet. d=0.6778 feet.

9	35.280	30.058	68.8	522.7	0.003898	56.454
10	35.278	30.057	69.05	522.7	0.003890	56.249
11	35.230	30.054	69.17	522.7	0.003910	56.152
12	35.235	30.053	69.17	522.7	0.003913	56.152
13	35.265	30.052	68.92	522.7	0.003907	56.355
14	35.262	30.049	68.55	522.7	0.003865	56.659
				Mean.....0.003897		

*In experiment No 2 there was evidently an error in observing the time of transit.

First Philadelphia Experiments 8⅛-In. Tube.

On May 5, 1901, a series of experiments were made in Philadelphia with the 8⅛-in. tubes that are used to transport mail between the general post office and the Pennsylvania Railroad station at Fifteenth and Market streets. Like the tubes leading to the Bourse, these tubes are of cast iron, bored, with bends of seamless brass; the bends, however, are one-quarter of an inch larger in diameter than the straight part of the tube. In computing the values of the co-efficient the average diameter was used, but the bends are such a small part of the circuit that their effect is very slight. A small correction was made in the pressures for the resistance of the switches opposite the Reading Railway station. The experiments were made in the same manner as those already described with the tube to the Bourse. The power was supplied by an air compressor located at the Pennsylvania Station, which pumps directly into the tube. The air flows to the post office and returns, the pressure in the tube being at all points above atmospheric. The return end of the tube is open to the atmosphere.

By Prof. Unwin's formula the value of the co-efficient for a tube 0.6778 ft. diameter is

$$0.0027 = 1 + \frac{3}{10 \times 0.6778} = 0.003895$$

Second Philadelphia Experiments 8⅛-In. Tube

After the experiments of May 5 and June 28, 1901, I decided to make another series with the 8⅛-in. tube from the post office to the Pennsylvania Station, taking greater pains to have the packing of the carrier air tight, and making more accurate measurements of the frictional resistance of the carrier during the experiments. To this end the friction of the carrier was measured frequently during the experiments by pulling it through a section of the tube with a spring balance. The resistance was considerable at the beginning of the experiments, but diminished as the packing became worn. The measurements of carrier resistance are plotted in Fig. 15, with the numbers of the experiments as abscissæ. A smooth curve was drawn and ordinates of this curve were used to correct the initial pressures by subtracting

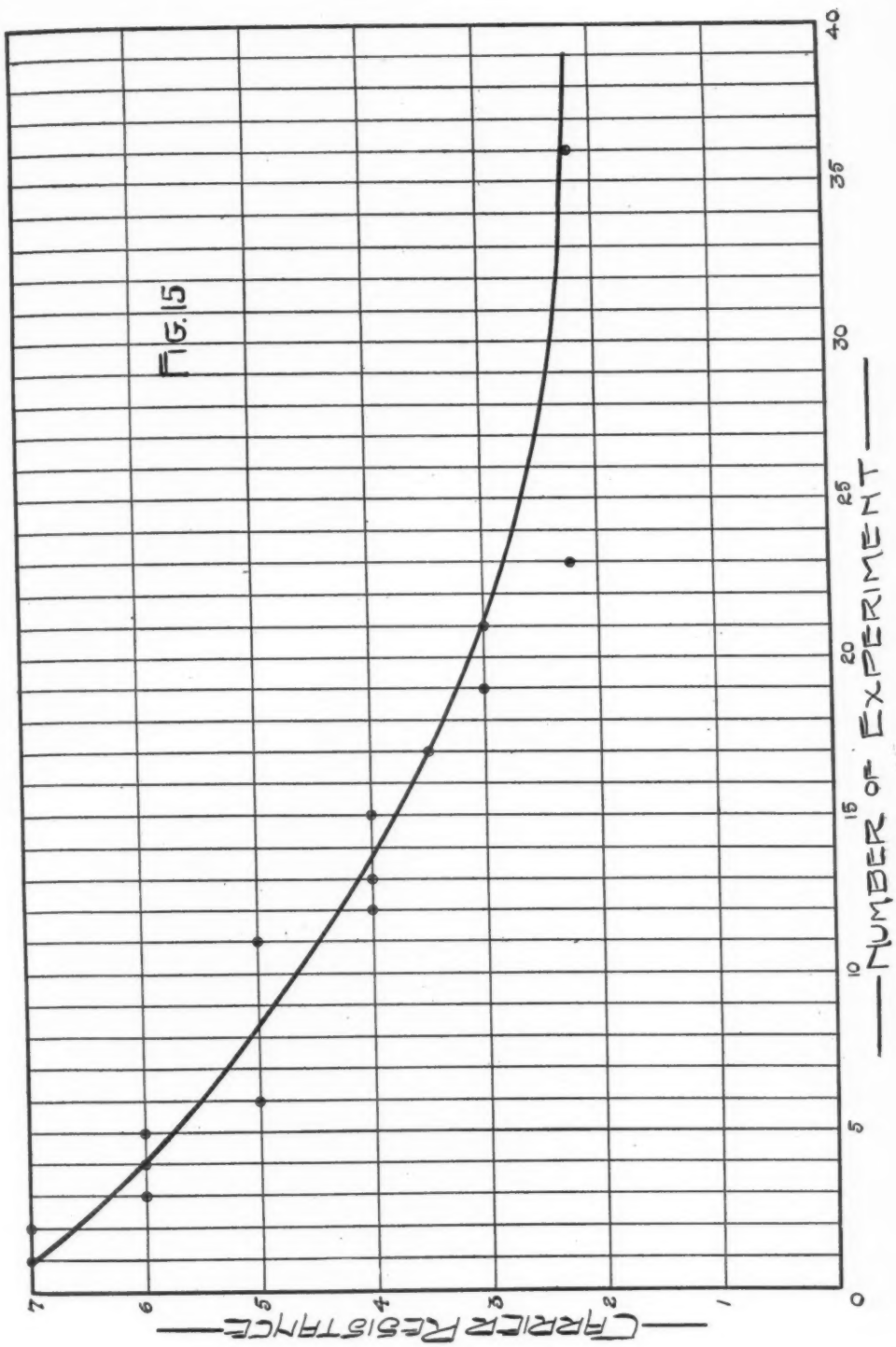


FIG. 15
CARRIER RESISTANCE
NUMBER OF EXPERIMENT
0
5
10
15
20
25
30
35
40
1
2
3
4
5
6
7

the carrier resistance expressed in inches of mercury per square inch.

Number of Experiment.	Resistance of the Carrier. Pounds.	Number of Experiment.	Resistance of the Carrier. Pounds.	Number of Experiment.	Resistance of the Carrier. Pounds.
1	7	6	5	17	3½
2	7	11	5	19	3
3	6	12	4	21	3
4	6	13	4	23	2¼
5	6	15	4	36	2¼

The range of the experiments was made as great as possible from the lowest to the highest practical carrier velocity.

The following tables contain a summary of the experiments:

helped in the estimation of their magnitude. The precision of the pressure, time and temperature measurements is undoubtedly high and the dimensions of the tube are accurately known. The source of greatest error probably lies in the disturbing effect of the carrier resistance and escape of air past the carrier, but an effort was made to make errors from these sources inappreciable. In the case resistance of the carrier is greater than the amount allowed, the resulting value of f will be too large, and the escape of air past the carrier has the same effect. The method of correcting for the resistance of the carrier by subtracting the pressure necessary to move the carrier from the recorded initial pressure is not strictly correct, but the correction is so

EAST BOUND TUBE—JULY 9, 1901.

L=3882 feet. d=0.6778 feet.

Number of Experiment.	Mean Initial Absolute Pressure. Inches of Mercury. p_1	Mean Final Absolute Pressure. Inches of Mercury. p_2	Time of Transit. Seconds. t	Absolute Temperature. Fahrenheit. T	Coefficient of Friction. f Computed by (35)	Mean Carrier Velocity. Feet per Second. Um
1	33.043	31.542	135.84	541.0	0.004599	28.578
3	32.546	31.294	146.63	541.1	0.004523	26.475
5	32.792	31.401	141.24	541.3	0.004638	27.485
7	32.678	31.353	143.37	541.2	0.004563	27.077
9	32.720	31.352	142.24	541.2	0.004628	27.292
11	32.614	31.306	145.88	541.2	0.004672	26.611
13	32.813	31.405	144.88	541.3	0.004938	26.795
15	31.747	30.889	178.52	541.3	0.004685	21.745
17	31.986	30.987	167.00*	541.3	0.004748	23.246
19	31.872	30.937	172.24	541.3	0.004739	22.539
21	31.868	30.938	174.25	541.3	0.004822	22.278
23	31.981	30.968	167.12	541.4	0.004826	23.229
25	36.313	33.221	92.65	541.4	0.004092	41.900
27	36.010	33.046	94.41	541.4	0.004102	41.118
29	36.066	33.101	94.66	541.5	0.004119	41.010
31	36.051	33.088	94.41	541.5	0.004096	41.118
33	39.602	34.972	77.08	541.6	0.003951	50.363
35	39.144	34.598	78.59	541.6	0.004079	49.396
37	39.914	35.081	76.06	541.6	0.003995	51.025
39	39.460	34.864	77.84	541.7	0.004014	49.872
41	44.774	37.733	64.53	542.0	0.003801	60.158
43	45.076	37.740	64.28	542.0	0.003913	60.392
45	46.007	38.340	62.77	542.2	0.003829	61.845
47	47.611	39.223	60.24	542.3	0.003746	64.442
49	47.894	39.470	60.00	542.3	0.003710	67.700
51	39.019	37.774	163.20	542.5	0.004644	23.787
53	38.413	39.936	146.63	542.3	0.004531	26.475
55	37.988	36.422	141.36	542.2	0.004481	27.581
57†	50.166	47.497	115.50	542.0	0.003916	33.610
59†	51.452	48.548	111.73	542.0	0.003894	34.745
61†	51.023	48.440	119.52	542.2	0.003987	32.480

*Time of transit, approximate.
†Valve at the open end of the tube was partially closed to increase the pressure throughout the tube.

The best measure of the precision of these experiments is the agreement of the results among themselves and the agreement of experiments made on different days. The experience of the earlier experiments was of great assistance in securing better results later, since it pointed to probable sources of errors and small that I believe the error of this method is negligible. No correction was made for the acceleration of the carrier. The size and length of the tubes in which these experiments were made give weight and value to them.

The values of f obtained from all of the foregoing experiments are plotted to a large

WEST BOUND TUBE—JULY 9, 1901.
L=3884 feet. d=0.6778 feet.

Number of Experiment.	Mean Initial Absolute Pressure. Inches of Mercury. P_1	Mean Final Absolute Pressure. Inches of Mercury. P_2	Time of Transit. Seconds. t	Absolute Temperature. Fahrenheit. T	Coefficient of Friction. f Computed by (35)	Mean Carrier Velocity. Feet per Second. Um
2	31.257	30.043	145.13	541.4	0.004470	26.762
4	31.307	30.043	143.12	541.4	0.004522	27.138
6	31.331	30.046	142.11	541.4	0.004531	27.331
8	Record lost—	Carrier	lodged in	transmitter.		
10	31.286	30.053	144.63	541.4	0.004505	26.855
12	31.361	30.053	139.35	541.4	0.004434	27.872
14	31.368	30.052	139.36	541.4	0.004459	27.870
16	31.004	30.050	168.98	541.4	0.004782	22.985
18	30.974	30.048	169 23	541.4	0.004682	22.951
20	Record lost—	Carrier	lodged in	transmitter.		
22	30.896	30.043	179.00*	541.4	0.004807	21.698
24	31.000	30.045	168.00*	541.4	0.004732	23.119
26	33.120	30.141	90.14	541.3	0 004094	43.088
28	33.081	30.147	90.89	541.3	0.004102	42.733
30	32 962	30.142	92.90	541.3	0.004127	41.809
32	33.051	30.152	91.40	541.3	0.004101	42.495
34	34.636	30.208	74.57	541.3	0 004057	52.085
36	34.693	30.216	73.32	541.3	0.003961	52.973
38	34.913	30.227	71.56	541.3	0.003934	54.276
40	34.785	30.224	72.82	541.3	0.003974	53.337
42	37.746	30 343	57.50	541.3	0.003822	67.548
44	37.889	30.354	55.25	541.3	0.003583	70.299
46	38.565	30.373	53.98	541.3	0.003676	71.953
48	39.436	30.411	51.72	541.3	0.003663	75.097
50	39.296	30.408	51.98	541.3	0.003652	74.721
52	37.209	36.416	205.63	541.3	0.004880	18.889
54	36.752	35.715	179.78	541.3	0.004956	21.604
56	36.790	35.636	169.73	541.3	0.004921	22.878
58†	47.915	46.161	149.90	541.3	0.004488	25.911
60†	48.547	46.577	142.61	541.3	0.004513	27.235
62†	48.536	46.774	153.92	541.3	0.004693	25.234

*Time of Transit, approximate.
†Valve at the open end of the tube was partially closed to increase the pressure throughout the tube.

scale in Fig. 16, with mean velocities for abscissa to discover, if possible, whether or not *f* is a function of any other factor in the equation.

The most striking features of these results are the variation of *f* with the diameter of the tube and the apparent variation with the velocity. In view of the experiments of others, there can no longer be much doubt that the value of *f* does depend upon the diameter of the tube. For velocities about 51 or 52 ft. per second, Prof. Unwin's empirical formula fits the experimental values very closely.

In regard to the variation of *f* with the velocity, while it seems at first so apparent, I am not prepared to say that it has been demonstrated beyond all question, and the doubt will remain until these results are confirmed by other experiments, using some different method. It is possible that *f* varies not with the velocity, but with the density of the air. To throw some light on this suggestion, the experiments of July 9, numbering 57 to 62 inclusive, were made with the valve at the open end of the tube partially closed, which raised the pressure throughout the tube.

Experiments 57, 59 and 61 gave decidedly lower values for *f* than experiments at the same velocity, with less density. The same difference is not so marked in experiments 58, 60 and 62, with the best-bound tube. For the same velocity, the density of the air was always greater in the east than in the west bound tube, because it flowed first east and then west. If the value of *f* depends upon the density, we should not expect a curve of the experiments with the east-bound tube to coincide with a similar curve of the west-bound experiments, but there does not appear to be much difference—the results were about the same with either tube.

The apparent variation of *f* with the velocity may have been in part due to the disturbing effect of the carrier. The corrections of the initial pressures for carrier resistance were proportionately larger when the velocities were low. With a velocity of 20 ft. per second, a variation in the initial pressure of 0.01 inch of mercury makes a variation of 0.000065

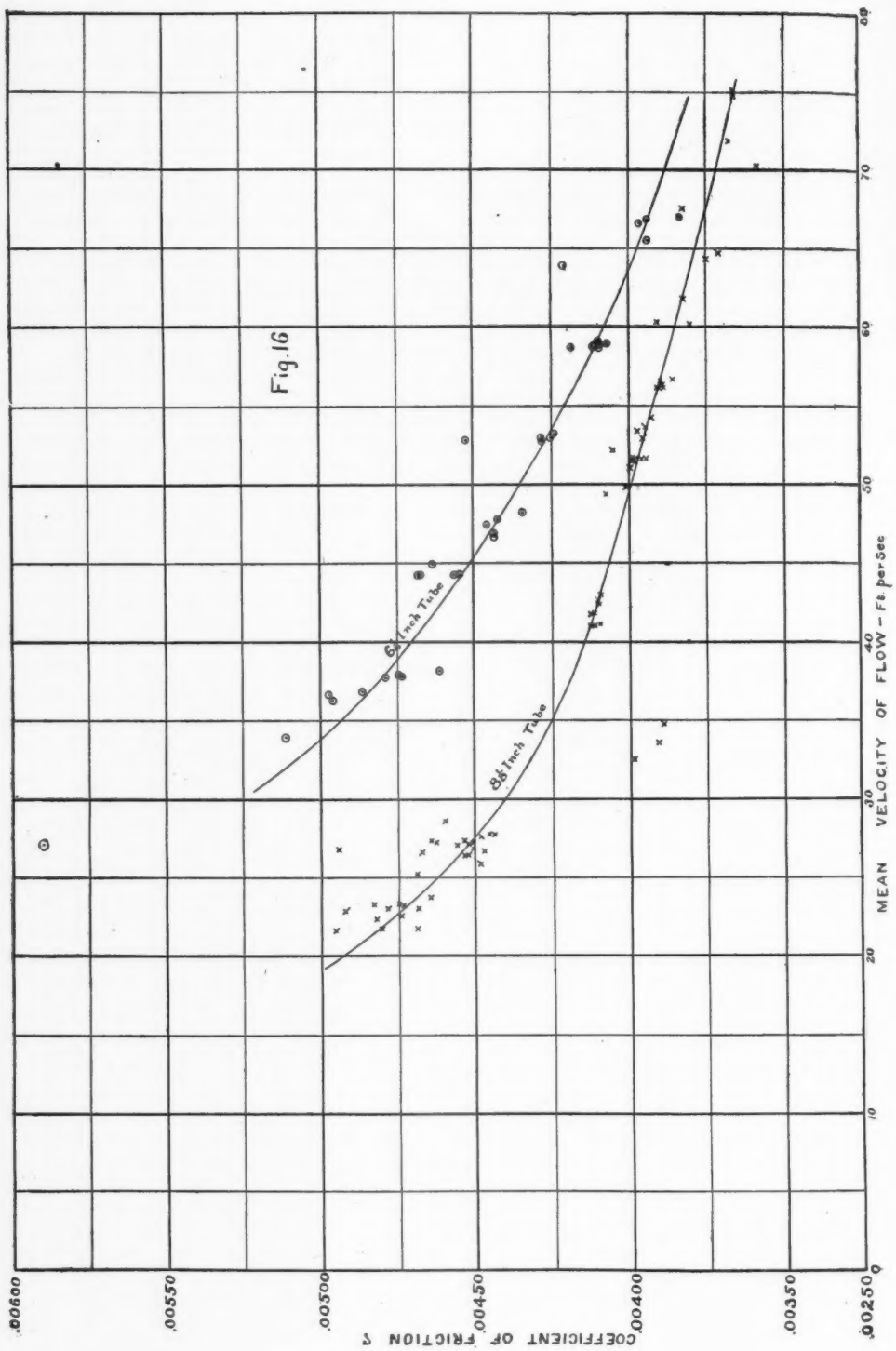


Fig. 16
6¼ Inch Tube
8¾ Inch Tube
COEFFICIENT OF FRICTION f
.00600
.00550
.00500
.00450
.00400
.00350
.00250
MEAN VELOCITY OF FLOW – Ft. per Sec
0
10
20
30
40
50
60
70

in *f* in the 6⅛-in. tube. I do not believe that errors from this source account for all the variations, for on July 9 the first and last experiments (exclusive of experiments with the valve at the end of the tube partially closed) were made with low velocities, purposely so arranged to detect, if possible, any effect due to the wear of the carrier. The carrier resistance had fallen from 7 to 2¼ lbs., and yet the resulting values of *f* are practically the same—the later experiments are a trifle higher in the west tube.

(*To be continued.*)

The seventh annual session of the Summer School for Artisans held under the direction of the College of Engineering of the University of Wisconsin begins June 24th, and continues for a period of six weeks.

Courses of study are offered in the following subjects:

1. Engines and Boilers.—Lectures and laboratory courses covering the theory, construction, management and testing of steam engines, boilers, gas engines and gas producers, refrigerating machines, etc.

2. Applied Electricity.—Lectures and laboratory courses covering the theory of direct and alternating current dynamos and motors, the operation and method of testing electrical machinery, batteries, transformers and other apparatus, photometry, and calibration of instruments.

3. Mechanical Drawing and Machine Design.—Elements of applied mathematics, courses in mechanical drawing and machine design adapted to the preparation of the students.

4. Materials of Construction, Fuels and Lubricants.—Lectures on the properties of materials accompanied by laboratory tests; lectures on fuels and lubricants with laboratory tests on the heating value of coals and efficiency of lubricants.

5. Shop Work.—Practice with hand tools, wood and metal working machinery, and in blacksmithing and pattern-making.

6. Manual Training.—Lectures and laboratory courses adapted to the requirements of manual training teachers.

The entire laboratory and shop equipment belonging to the College of Engineering is used by the students in the summer school.

The requirements for admission do not extend beyond a working knowledge of English and arithmetic, but the policy is to allow a large amount of individual work so that the student may take advantage of all the preparation he has obtained.

This school offers to those unable to take a regular year's course an opportunity of obtaining a working knowledge of the methods of testing and the use of instruments, together with such theoretical principles in each case as the nature of the subject and the preparation of the student may permit.

Correspondence students have found this school of value in giving an opportunity for laboratory practice along the lines in which they have had theoretical instruction.

A bulletin describing the work of the School for Artisans in detail will be sent on application to Frederick E. Turneaure, Dean, College of Engineering, Madison, Wis.

The value of the pneumatic machine is apparent to every man who walks the street beside a new building in course of construction and hears the rattle of the hammers and riveters driven by compressed air and beating an unceasing tattoo upon the iron beams and girders. It is said that pneumatic drills and riveters are all the make modern steel constructions possible. The bolts must be driven home and tapped while they are yet hot, and in the heavy materials used now in bridges and skyscrapers it would be impossible to do this work by hand.

In another machine of the automatic class which still is in process of development compressed air is used for the various parts of the machine in order to present the tools consecutively to the work and for the motions necessary for the cutting operations. The extreme lightness of air as compared with the mechanisms ordinarily employed for this purpose enables the "idle motions" to be made much more quickly than otherwise possible. Thus the time consumed in the withdrawal of one tool and the presentation of another is reduced greatly.

In Norwich, Conn., compressed air has very generally replaced beer pumps in saloons, clearing the barrels more effectually than by the old method and at a cost of but $2.00 per month for each saloon.

THE COST OF A SMALL ROCK TUNNEL.*

Rock tunnels of small section are not frequently met with in the engineer's experience, and this fact probably accounts for the lack of data to be found in the text books and engineering periodicals on this subject. It poscost estimates and bid prices which have from sibly also accounts for the great variation in time to time come under the writer's observation; for unless an engineer has had actual experience in the construction of small tunnels, many of the items which go to make up their cost are either entirely overlooked or greatly underestimated.

Cost estimates for small tunnels are often based on the cost of running the heading in a large tunnel, which, of course, is perfectly correct in theory, but in practice usually results in an under-estimate of the cost of doing the work. This is brought about in the first place by the difficulty in separating the cost of heading from bench, as both classes of work are usually carried on at the same time, and in the second place by the fact that the volume of excavation in the bench is so much larger in quantity and cheaper in cost than the heading, that a slight error in distribution makes a large variation in the heading cost. Take for example the plant charges, depreciation, maintenance, etc.; this is usually divided by the total yardage of excavation, so that whether the excavation per day amounts to 100 cu. yds. for a large tunnel, or 10 cu. yds. for a small one, is of extreme importance.

The number of linear feet of hole drilled per cubic yard of rock is the determining feature of cost in all rock excavation, and when this runs from seven to ten linear feet of hole drilled per cubic yard in the heading, and perhaps but one or two feet per cubic yard in the bench, the wide difference in cost can be easily understood.

Powder is another large item of expense in small headings; to break out the first cut in a solid face of rock requires enormous force, quantities of dynamite. The writer has seen and this can only be obtained by using large as high as 9 lbs. of 60 per cent. dynamite used per cubic yard in hard rocks.

Another item which is generally over estimated is the average daily progress. Where it has been estimated that two shifts of drilling can be done a day, in practice it is often impossible to do so. The space for setting up the drills is extremely limited, so that the number of drills which can be economically worked is small, and if the rock is at all hard or seamy, ten hours is not more than enough to get the holes down. These holes have then to be loaded and fired and the tunnel cleared of fumes before the mucking gang can commence its work of clearing out sufficient loose material to set up the drill columns again.

There is still another item entering into the cost of small tunnels which is often lost sight of, and that is when the tunnel has to be lined with brick or concrete it is usually found uneconomical to do this work until the excavation has been completed. In other words, the space for tracks is limited, and it is apt to turn out that the interference of one class of work with the other is more costly than the delay of doing one class of work at a time.

There is usually a clause in the specifications which defines a circumference beyond which excevation will not be paid for, and in this lies another item of expense which the contractor's engineer is liable to under-estimate; for the smaller the tunnel the larger is the per cent. of circumference which will not be paid for per cubic yard of excavation. This excess yardage takes powder to loosen it and labor to remove it, and where it has to be replaced, as often happens, with concrete or rock paving without additional charges, the cost is often a heavy one. Twelve to 15 per cent. additional excavation beyond the neat excavation line in good firm rock has been met with.

The main items of expense in a small tunnel which came under the writer's experience were as follows:

The tunnel was about 3,000 ft. in length in hard trap rock, 9 ft. in diameter, and approximately circular in section running 2,46 cu. yds. of excavation per linear foot of tunnel. The air was piped to each end of the tunnel from a central plant, and both headings were run simultaneously. The plant consisted of two 75 H. P. Rand straight line compressors rated at 390 cu. ft. of free air per minute at 80 lbs.; three 100 H. P. locomotive boilers, together with air receiver, pumps, nine Rand Little Giant No. 3 drills, 20 tons, 12-lb. rails, and fittings, 5,000 ft. 4-in. wrought iron pipe and six 24-in. gage, ¾-yd. ore cars. A 10 H. P. Fairbanks Morse gasoline engine belted to 7 K.W. dynamos furnished light in the tunnel. Four drills were used at each heading and drilled in 10 hours 8 cut holes 7 ft. deep, 6 side holes 6 ft. deep and 3 top dry holes 6 ft. deep or 110 ft. The average cut pulled was 5 ft. or 12.3 cu. yds. at each heading. When the holes had been drilled the powder gang took down the column and drills, loaded and fired the holes; after which the mucking gang shoveled the loose rock into ¾ cu. yd. iron tunnel cars, which were drawn by a mule on a track made up of 12-lb. rails to the dump.

Figures 1 and 2 show the position and spacing of the holes in the tunnel. The eight center holes are the cut holes and are pointed slightly downward so as to hold water and at such angle with the direction of the tunnel that their far ends or bottoms come close together. The six side holes are also pointed

*Francis L. Pruyn, Assoc. M. Am. Soc. C. E.

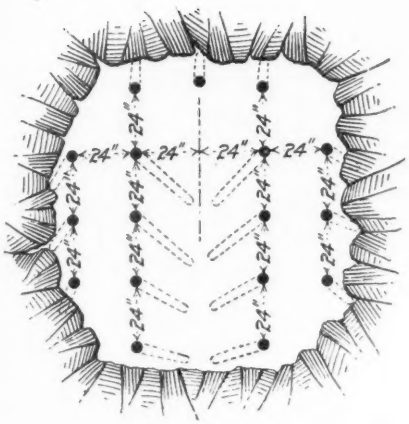


Fig. 1.

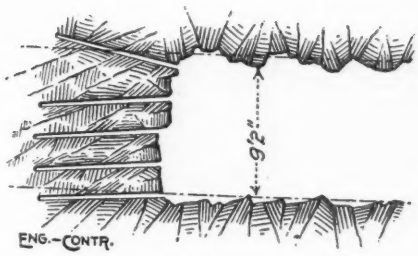


Fig. 2.

slightly downward and in such a way that their far ends extend outside the lines of the tunnel, so that the rock will break to proper line. The three top holes are dry and are pointed slightly upwards, so that their far ends will be a little above the grade of the roof.

The drilling shift started in at 7A. M. and, on an average, it took 2½ hours to set up the columns and machines. They then drilled their heading and finished at 5 P. M.

The blasting gang then loaded and fired the holes so that the muck would be ready for the mucking gang which came on at 7 P. M. and worked until 5 A. M.

Seventy-five per cent. dynamite was used on this rock. It was seldom that the cut would pull clean to the bottom on the first shot and almost always an additional loading at the bottom of these holes was required before the full depth of the cut was reached.

The cost of the average labor force for the twenty hours during which time 10 lineal feet of tunnel at 2.46 cu. yd. per ft., were excavated, is shown to be equivalent to $23.02 per lin. ft. of tunnel.

The cost of the average labor force for 20 hours was as follows:

	Per day.	Per cu. yd.
Office:		
1 Superintendent at $250.00	$9.60	$0.39
1 Timekeeper at $65.00	2.50	0.10
Compressor:		
1 Compressor Engineer	5.00	0.20
2 Firemen	4.00	0.16
1 Electrician	4.00	0.16
Plant Labor:		
1 Master Mechanic	5.00	0.20
2 Pipe Fitters	6.00	0.24
2 Blacksmiths and Helpers	10.00	0.41
2 Walking Bosses at $5.00	10.00	0.41
8 Drill Runners and Helpers at $5.00	40.00	1.63
2 Nippers at $2.00	4.00	0.16
1 Blaster	5.00	0.20
2 Blaster Helpers at $2.00	4.00	0.16
2 Mules and Drivers at $4.50	9.00	0.37
12 Laborers at $1.50	18.00	0.73
2 Laborers' Foremen at $3.50	7.00	0.29
Total Labor	$143.10	$5.81
Insurance at 6 per cent.	8.58	0.35
	$151.68	
Powder, Exploders, Wire, etc., 8 lbs. per cu. yd. at 18.1 cts.	35.60	1.44
Coal, 4 tons, at $4.00	16.00	0.66
Gasoline for Lighting	2.88	0.12
Plant, including depreciation, repairs, drill steel, hose, etc., at $1 per cu. yd.	24.00	0.98
Total, 24.6 cu. yds. at $9.36 per cu. yd.	$230.16	$9.36

COMPRESSED AIR: ITS PRODUCTION AND USE.

English practice in the application of compressed air follows very closely the methods employed in this country, and the point of view taken by our cousins across the water is very interestingly presented by A. L. Daw of London, whose contribution to the literature on this subject is given in part.

HISTORICALLY CONSIDERED.

The use of air under pressure in the forge and in the reduction of metals from their ores has been known from the earliest ages, but its introduction to modern engineering seems to have been by Smeaton, in 1776, in diving bells for submarine work. Its first practical employment on a large and important scale was, however, by M. Sommelier, in 1860, at the Mont Cenis tunnel. From this its introduction into mining followed rapidly, as in all such operations it has especially great advantage over every other form of power, for, besides serving to transmit the required power, the exhaust air from the machines underground greatly aids the ventilation.

Recent years have marked an ever-extending use of compressed air for power transmission plants, and also for manufacturing purposes. Almost every modern engineering shop is now equipped with a compressed air power plant for the driving of all kinds of pneumatic, caulking, chipping and portable tools, riveting machines, traveling cranes and lifts, and in foundry work and numerous other appliances, and its use in almost every field of industry is daily spreading.

PRODUCTION.

Free air is drawn from the atmosphere into a cylinder, where it is compressed and discharged into a receiver for distribution through the mains to the points of application, and the efficiency of the process depends upon the passing of the *maximum* volume of air through the compressor cylinder for any given expenditure of power, and thus the construction and design of the compressor cylinder, its valves and piston are of the very first importance, as they are the primary instruments concerned.

CONDITIONS TO BE FULFILLED IN A PERFECT COMPRESSOR.

1. On the suction stroke the compressor should throughout the stroke fill with air at the exterior pressure.

2. The air should enter in a large stream with the least possible contact with the hot surface of the valves and cylinder that its temperature may be raised as little above the outside temperature as possible.

3. On the compression stroke there should be no loss of any portion of the contained air by reflux to the atmosphere by too late closing of the inlet valve, nor should there be any leakage back, but the whole contents of the cylinder, less the minimum of clearance, should be discharged through the outlet valve.

4. The outlet or discharge valve should have ample area of opening, should open automatically on the pressure in the receiver being reached in the compression cylinder, and the air should be discharged at a pressure as little above that in the receiver as possible, as excess pressure causes a rise in temperature with increase in volume, requiring a corresponding increase in the work necessary to compress and discharge the air.

5. The discharge valve should have sufficient width of seating to insure its keeping quite tight that no loss by leakage back into the cylinder may take place.

6. The valves should be self-adjusting under all speeds and pressures.

7. Full volumetric efficiency.

8. All the valves and the piston should be easily accessible for examination and renewal.

9. Wear and tear should be reduced to a minimum.

It will be evident from the above that the construction of an air compressor is a very different problem than the mere building of an air pump, and that it calls for a full technical knowledge, combined with practical experience in the building and use of such machines.

COMPRESSOR VALVE SYSTEMS.

An examination into the construction of air compressors will show that they may be broadly classed as below, according to the manner in which their inlet and discharge valves are actuated.

1. In which poppet valves are used for both the inlet and discharge of the air, arranged.
   - (*a*) In the cylinder covers.
   - (*b*) Partly in the cylinder covers and partly in the cylinder walls.
   - (*c*) With inlet valves in the piston and with discharge valves either in the cylinder covers or walls.
2. With large hinged flap valves arranged

in the cylinder covers and actuated similarly to poppet valves.

3. With mechanically operated inlet and discharge valves which open and close gradually through direct mechanical connections.

4. With inlet valves mechanically operated and with poppet discharge valves.

Poppet valves require to be small in diameter and light in weight, and to have a small lift to prevent hammering. The valve area is in consequence necessarily restricted to the minimum, and a common defect is insufficient space for the inlet of the air and for its proper discharge after compression. As poppet valves have no tendency to close by themselves, they require strong springs to insure their proper action, and therefore the cylinders to which they are fitted *never* can fill to the full exterior pressure because, as is evident, to open and keep open the valves there must always be such difference between the inside and outside pressure as is necessary to overcome the resistance of the spring, and the result of this is loss of power. This loss of power is further increased by the air being unnecessarily heated by coming in contact with the hot surface of the valves and seatings through being drawn in in a thin stream, and more especially is this the case when the inlet valves are placed in the piston, as then the air comes in contact with the hot piston and also of necessity with a long hot admission tube.

Large hinged flap valves arranged in the cylinder covers have the advantage over poppet valves of larger valve area, but require heavy springs to close them, and as with poppet valves the cylinder in consequence never can fill with air at the exterior pressure for reasons given above. Further, the large size of the valves necessitates an elaborate arrangement of spring frictional and other buffers which limit the speed and output of the compressor.

With valves operated through direct mechanical connections there are many difficulties in the way of positive movement, and especially of such movement in the discharge valves, as the point of discharge varies with the pressure, and this is effected more or less by the conditions of temperature, density and moisture of the inlet air, and the cooling effect during compression. The discharge valve should open when the pressure in the receiver has been reached in the cylinder if loss of work is to be avoided, and equally serious in loss of efficiency would it be to open a discharge valve before the receiver pressure has been reached in the cylinder. A further grave defect with many mechanically operated valves is that the discharge opening is closed gradually toward end of stroke, compelling, by great rise in pressure, the last portions of air to pass the valve at excessive speeds with rapid rise in temperature much beyond the temperature of discharge, with attendant danger of explosion should there be an excess of lubricant or should a lubricant of inferior quality be used.

The ever-varying conditions make the operation of compressor valves mechanically so unsatisfactory in practice.

TRANSMISSION.

The transmission of power, to a greater or less distance, is a problem that frequently engages the serious consideration of the engineer. The means at his disposal are steam, water, wire rope, electricity and compressed air, and the advantages of each of these systems vary with the conditions attending their application.

Of the first three the merits and limitations are too familiar to require enumeration, and the choice is limited to electricity or compressed air when the distance of transmission exceeds a limited range.

The applications of electrical energy to industrial uses have received so much attention at the hands of scientists, engineers and capitalists, that the greater economy and suitability of compressed air to many of these uses have been thereby forced into the background and neglected. Further, experience has shown that the high efficiencies first claimed for electricity have failed to be verified, and the rapid strides made in the production of compressed air with the greater knowledge gained in its transmission and use is directing more and more attention to this somewhat neglected force as a means of power transmission.

With electricity the cost of the wire governs the voltage, which, when the power has to be transmitted a distance, varies between 2,000 and 50,000 volts, if the cost of the wire is to be kept within reasonable limits. The voltage or electric pressure after transmission has to be brought down to the proper limits for safe distribution and use, necessitating the employment of step-up and step-down transformers. There are the following stages in the production and use of electric power in distance transmission:—

1. The engine or motor.

2. The dynamo.
3. The step-up transformer.
4. The cable transmitting the power.
5. The step-down transformer.
6. The cable distributing the power.
7. The electric motor developing the power after its transmission.

And, although the efficiency of the modern dynamo is a triumph to the skill of the electrical engineer, the power, as seen above, is transformed so many times between the generating station and point of application that, notwithstanding the high efficiency of the dynamo, the efficiency of the whole system is probably not greater than 50 per cent.

Further, the electrical apparatus, with its multiplicity of transformers, high potential insulators, and other high potential devices, is exceedingly liable to break downs and necessitates constant supervision by skilled men.

In power transmission by compressed air there are the following stages:

1. The compressor.
2. The pipe line.
3. The motors.
4. The re-heater for re-heating the air before admission to the motors if the fullest economy of the system is to be utilized. Without re-heating the efficiency of the system should be 45 per cent., and with re-heating from 55 per cent. to 60 per cent.

The first point to be decided by the engineer is the pressure at which the air shall be transmitted, as this governs the type of compressor and the size and cost of the pipe line. For long distance transmission the power can be commercially most economically transmitted at high pressure of from 120 to 150 lbs. per square inch, the pressure being reduced at the point of distribution in accordance with requirements.

The next point to be determined will be the pipes to be employed, in which the considerations of most importance are the material, diameter and character of the joints.

With regard to the motors, these of course are governed by the pressure at which the air is to be used and the work to be done.

As to the re-heating of the compressed air after transmission and before admission to the motors, users generally have as yet failed to recognize the importance thereof, although a large increase in efficiency is thereby obtainable, and any practical difficulty due to the cooling of the air in expansion in the motor entirely obviated. Air at 32 deg. Fahr. expands on heating 1/461 part of its volume for each degree Fahrenheit, and thus the re-heating of the compressed air before use in the motor is of the greatest commercial importance, as less air is required per stroke of the motor. The economy gained will, of course, depend on the relation between the additional work obtained and the fuel expended. Experience shows that the heat supplied is used with great efficiency, and that by heating the air before use the work done per pound of air may be increased from 25 to 40 per cent.

A further point of great advantage in the adoption of power transmission by compressed air is that the compressor, pipe line and motors are all easily understood and operated by mechanics accustomed to the use of ordinary steam engines, and thus the necessity for specially trained skilled men is obviated.

BOBBINITE THE LATEST COAL-GETTING EXPLOSIVE

There is no such thing as a completely safe explosive—that is to say, there is no explosive known which, under any conceivable circumstances, might not ignite gas or dust, or a mixture of gas and dust. But the relative safety of the very best and highest class of explosives, as compared with gunpowder, is so great that the difference of safety in degree practically becomes a difference in kind.

Bobbinite is classed as a non-detonating mechanical mixture which consists of a high-grade gunpowder containing but little sulphur, mixed with starch and paraffin-wax, and compressed into a pellet coated with paraffin-wax. It was tested in various ways, and practical experiments were conducted with it in four seams of widely varying character, when it produced marked advantages in coal-getting over other substances of a similar type. It is the opinion, however, that the experiments indicated that Bobbinite and several other explosives of this character, where insufficiently confined, are more likely to explode gas than those explosives which give a high "charge limite" when tested without stemming. The "charge limite" is defined as the maximum charge which, in a series of ten shots fired unstemmed from a gun, fails to ignite an explosive mixture of gas and air in an experimental gallery.

COMPRESSED AIR

Established 1896.

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AT GREAT DEPTHS WITH COMPRESSED AIR

The remarkable success which engineers have made in driving tunnels under rivers and other important waterways in various parts of the world, has led to a serious consideration of employing similar methods for establishing subaqueous passages beneath straits, bays and even the ocean itself. From the constructional point of view, there is not the slightest doubt of its feasibility for what has been done so satisfactorily in many cases can be extended to a far greater degree.

At the present time financial reasons would alone seem to prevent the boring of tunnels between Europe and Africa, or Asia and North America, since the expense would be, perhaps, larger than the ultimate advantages to be secured. Furthermore, in the face of the diplomatic relations existing between world powers, such engineering feats appear to be well-nigh impossible. However, apart from this, engineers regard with confidence the proposition of sub-ocean tunneling because the achievements already attained have been due to the development of the compressed air system. At first, when this system was introduced, its possibilities were only conjectural, for its beginnings were small inasmuch as it was used for driving bores, making foundations for bridges and wharves under river beds and in water-bearing strata generally. But it has developed steadily, until now work is carried on with safety and with certainty as regards its final result, at depths up to nearly 120 ft. below high-water level, involving an air pressure of 40 lbs. per square inch above the atmosphere. In fact, in nearly every instance, where water is likely to be encountered, compressed air is now adopted, for engineers prefer to use it as a safeguard against any emergency. Whether compressed air can be applied for deep-sea boring is still largely a matter of experiment. Still, the shield system has operated so accurately in all cases with such practical results, that its application to engineering problems of such magnitude as referred to above, is highly probable.

CASTING AIR COMPRESSOR CYLINDERS

Cylinders of air compressors, gas engines, and some steam engines are often exceedingly intricate in design; due in the case of the two former, to the presence of the water jacket, while in high-grade steam engines a steam jacket is often provided. Where these cylinders are cast in one piece, it is obvious that great care must be exercised to eliminate flaws, and even when cylinder liners are used, the process is a most important one. There has lately been manifested considerable interest in processes that will insure better castings, by introducing small quantities of titanium into the molten metal just before pouring, thus purifying it, and increasing its fluidity, making the pouring of complicated and intricate castings a less difficult operation. Readers of COMPRESSED AIR will probably be interested in knowing of an easy method of accomplishing these results. In fact, the process is so simple that it is within the reach of all who desire to increase the quality of their product. It consists of introducing a specially prepared can of titanium Thermit into the ladle and allowing it to burn while at a point near the bottom.

To those who are not familiar with the composition of Thermit it might be well to state

that it is a mixture of finely divided aluminum and iron oxide, which, upon ignition reacts to form aluminum oxide and pure molten iron or steel (according to the quantity of carbon introduced) at a temperature of 5400 deg. Fahr. Titanium Thermit is a mixture of ordinary Thermit and titanium oxide, which reacts to form liquid iron and metallic titanium, as aluminum unites equally well with the oxygen of the titanium oxide as it does with the iron oxide.

Titanium has a great purifying effect on molten iron, as it combines with the nitrogen in the liquid, forming cyanonitride of titanium. By this reaction, in conjunction with the heat of the Thermit reaction, a strong seething motion will be produced throughout the entire mass of the metal. Gases will be driven out and the liquid will show a white color almost as of steel, proof of its high temperature and fluidity. On analysis, however, the cast iron will not show any traces of titanium, other than what is in excess of the contents of the nitrogen.

The process is particularly valuable in the pouring of castings requiring a smooth finish, or that will be subjected to high pressures and great friction. In fact, it will be found that parts cast from this purified metal will possess an increased strength of at least 10 per cent. and will be of very fine grain.

It should be evident that the process is especially applicable to the casting of cylinders for air compressors, gas engines, steam engines, ammonia compressors, and hydraulic fittings of every kind, where strength, durability and high finish are required.

CARE OF AIR COMPRESSORS.

Valves which stick can often be successfully lubricated and kept in good condition by use of a little kerosene oil, applied with the usual machinery oil can.—*Mining & Scientific Press.*

We quote the above paragraph to show how some people may be misled regarding the handling and care of air compressors, and because we believe that such articles as the above are often responsible for serious accidents. Kerosene oil ought never to be used in this way, and if used at all on the air cylinder, great care should be taken to remove all of it before starting up the compressor. A much better and safer way of cleaning the cylinder and valves is to feed ordinary soapsuds through the cylinders for several hours every week or two. It may be passed through the lubricator instead of oil, but care should be taken to run with oil for a while after its use, before shutting down, in order to prevent rusting.

It is a very good practice to keep an extra set of outlet valves on hand, as this enables the engineer, at any time, to replace those on the compressor with clean ones. The change may be accomplished in a very few minutes and the dirty valves may be thoroughly cleaned by the engineer at his leisure.

COMPRESSED air seems likely to be used more extensively as machine tools are developed. The rapidity and facility with which it can be conveyed and its small mass make it well adapted for use in metal working machinery. In fact, its extreme rapidity needs to be checked in some instances where uniformity of motion is required under varying resistance, and this check is applied by the use of a body of water or oil, which is forced by the air pressure through a restricted but usually adjustable opening, and in turn acts upon the mechanism to be moved. The liquid, by resisting sudden changes in its rate of flow, regulates the speed of the motion.

A class of machines originally designed for making screws, but more recently employed also in making numerous small parts of machines and other articles, and known to the trade as "automatics," has been developed largely during the last five years.

At first these automatic machines would handle stock up to one inch in diameter only, and were used almost exclusively for making screws. They are made now to handle steel bars up to six inches in diameter, and are used for an almost endless variety of small parts. Many of these machines have a magazine attachment, by means of which castings or small forgings are fed successively to the machines. They require no attention whatever except to keep the magazine supplied with material and the various cutting tools sharp and properly adjusted.

A practical milking machine has been installed on the dairy farm of C. F. Moulton & Son at Cuba, N. Y., where 24 cows are now successfully milked twice each day by the new apparatus. A combination of the vacuum and compressed air systems is use the vacuum and compressed air systems is used.

NEW PUBLICATIONS.

The newest contribution to cement literature, and one for which there has been a demand for a long time, is "Concrete Factories," a series of papers descriptive of the uses of cement and concrete as applied in the construction of industrial plants. This book, which contains 152 pages, is compiled by Robert W. Lesley, associate American Society of Civil Engineers, and the editor of *Cement Age,* and is published by Bruce & Banning, 1 Madison avenue, New York.

This book offers in condensed form the most complete review of the principles underlying reinforced concrete construction that has yet been published, and has the still further advantage of being understood by the layman as well as the engineer. The book contains the report of the United States Advisory Board on fuels and structural materials, the report of the sub-committee on tests, the only translation of the French rules on reinforced concrete—which have just been issued by the Ministry of Public Works in France—and a number of profusely illustrated articles showing well-known reinforcing systems.

"Reinforced Concrete Construction," a chapter by Walter Mueller, is perhaps the most concise description that has yet appeared on the many concrete reinforcing systems now in the market, and "Concrete in Factory Construction," by E. A. Trego, reviews the work that has been done with concrete in the construction of industrial plants during the past few years.

"Concrete Factories" also contains "A Surface Finish for Concrete," by Henry H. Quimby, American Society of Civil Engineers, and a symposium of articles on the use of concrete in constructional work by Emile G. Perrot, C. A. P. Turner, E. P. Goodrich, J. R. Worcester, Dean & Main, Leonard C. Mason, E. S. Larned, Chester J. Hogue, J. G. Ellendt, and A. E. Lindau, and other eminent authorities on concrete construction work.

TRADE LITERATURE.

Latta & Martin Pump Company, Hickory, N. C.—A brochure, 20 pages, 11x8, describing in full the operation of their pneumatic displacement pumps, especially designed for manufacturing plants, mines and all centers where it is necessary to secure water quickly. Also there is a specially designed air lift showing its utility and the limitations for deep-well pumping. Included in this publication is a brief article on compressed air versus the steam pump.

G. L. Stuebner Iron Works, Lone Island, City, N. Y.—Catalog No. 50, 12 pages, 4x9, which deals exclusively with the Excelsior Bottom Dumping Buckets, which are particularly adapted to handle concrete, mud, sand, rock, etc. One of the chief features of these buckets is the locking device which holds the bottom in place and the operating mechanism is simple in design and extremely rapid.

Jersey City Crucible Company, Jersey City, N. J.—Booklet entitled, "A Study in Graphite," by Prof. W. F. M. Goss of Purdue University, 43 pages, 6x9, appealing particularly to those interested in short-cut methods of lubrication. This pamphlet covers in detail a series of tests of graphite not made with any special design to finding points for or against this material, but conducted in the spirit of scientific research. This study in graphite opens with an essay by Prof. Goss, based upon the conclusions drawn from the test. Complete descriptions of these are made, together with a number of illustrations of the testing machine. A summary of results obtained is shown in several tables, which are particularly valuable.

W. G. Leale Company, San Franicsco, Cal.—Pamphlet, 36 pages, 4x9, known as the Starrett System of Pumping by Compressed Air, covering a new process of pumping adapted for mining, windmills, irrigation, and high oil wells. Reference is made to their efficiency in high-duty plants and the illustrations prove their practical effectiveness.

Fairbanks Morse & Company, Chicago, Ill.—Profusely illustrated pamphlet entitled, "Practical Irrigation," 36 pages, 6x9, dealing thoroughly with mechanical irrigation problems and containing much pertinent data with reference to many different types of pumping machinery used for this purpose. The illustrations show the irrigating plants in actual operation, these installations covering a wide range of service, including pumps operated by gasoline, steam, electricity and the wind.

Webster Manufalturing Company, Chicago, Ill.—General catalog No. 30, 573 pages, bound in cloth, 6½x9¾, giving full and detailed information concerning the elevating, conveying and power-transmitting machinery manufactured by this company. This book is

superbly printed and illustrated, giving price lists of every sort and kind; also the machines and their parts. It is a useful compendium to which reference can be made by superintendents and managers of large manufacturing plants and power stations when new installations are being considered.

Robins Conveying Belt Company, 13 Park Row, New York.—Four-page leaflet, describing the installation of a package conveyor system in the new store of B. Altman & Co., Fifth avenue, New York. This circular is illustrated with cuts showing the working qualities of the belt and the central discharging point where the packages are received prior to their being placed in the delivery wagon. There are three conveying belts, 30 in. in width, 71, 91, 191 ft. in length, which operate on a series of idlers; also there is one large flat belt 36 ins. wide and 75 ft. long, guarded at the sides, being designed especially for the conveyance of unwrapped packages. These belts are entirely noiseless in operation, being so constructed that they perform the work quickly and efficiently with a minimum amount of friction.

CORRESPONDENCE.

To the Editor of Compresser Air:

Dear Sir—We have recently subscribed for your magazine, and you kindly favored us with some back numbers. We find in the April, 1906, number a picture of a portable electric motor for cylinder boring. We have lately been doing the same thing with the real thing, which is compressed air.

A cylinder of a locomotive on the P. and L. R. R. had the port so broken in that the only remedy was to put in a liner. We had it run on our siding and piped air about 600 feet to it, using a small steam engine which we ordinarily use for driving our boring bars with steam wher it is available. We bored out the cylinder, then inserted the lining and bored it in place, and the engine is now in service.

We enclose you a photograph we had made, showing the operation; and also a photograph of our works, which shows the location of the locomotive while the work was being done. The compressor is located in the building which has the taller of the two square chimneys, and is at the right of this chimney. You can see the pipe along the end of the brick building next the locomotive. This work was done in zero weather, and we were surprised at not having more trouble with the condensation freezing, but it gave us no trouble whatever. Yours truly,

POUGHKEEPSIE FOUNDRY AND MACHINE CO.
H. M. Bullard, General Manager.

INDUSTRIAL.

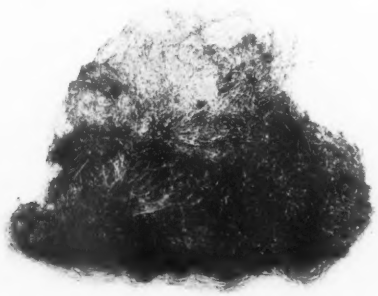
NEW EARTHQUAKE RESISTER.

The San Francisco disaster has just had its first anniversary. Some of the lessons are still fresh in the minds of those interested in municipalities. Careful men have personally inspected the ruins and made suggestions to architects, builders and engineers, based upon the data obtained during the inspection. But there is one field which has not been covered, and one danger that has not been brought as forcibly to the minds of municipal engineers

as its importance would warrant. And, strange as it may seem, this very one was responsible for more damage than the earthquake itself.

It will be remembered that San Francisco burned owing to lack of water, the water-pipes being disrupted during the earthquake. Has the question been sufficiently agitated, with a view to preventing such a cumulative disaster in the future? Have we any method of joining water pipes, so that a vibration, or a settling of the ground, will not strike paralysis to an entire city's fire protection?

This paper is glad to recognize any efforts which seem to point in the right direction, and which tend to lessen the risk from such causes.



SHREDDED LEAD.

A new substance is just being put upon the market by the United Lead Company, of 100 William street, New York, known as shredded lead, which is caulked into the joints in a manner quite similar to the caulking of the yarn in a stuffing box, but which has such a consistency as to make a perfectly tight, yet flexible joint, we are told. If such a thing can be made commercially practicable, the old method of pouring melted lead into the joint will soon become a thing of the past, as the shrinkage of the metal upon cooling materially weakens the joint and renders it subject to leaks upon the slightest provocation.

THE Consolidated Equipment Co., of 17 Battery place, New York city, have been appointed selling agents for the Emerson pump. This company's well-known triple vertical cylinder contractor's pump will be supplemented by a new product—the Emerson Junior. This latter is made with but a single cylinder, weighs but 219 lbs., and has a capacity of 100 gallons per minute against a 25-foot head, and about half this capacity on a 100-foot head. A stock of regular and Junior Emerson pumps will be kept on hand in New York and at the factory in Alexandria, Va., which is to be enlarged to accommodate this new design.

PURCHASING agents and those responsible for the materials which enter into the construction of cars, which will render the rolling stock immune from fire, are intensely interested in "Kantlite," a specially treated substance, of which Wendell and McDuffie, 26 Cortlandt street, New York, are the sole selling agents.

"Kantlite" is a fibre board which to make fireproof is subjected to chemical treatment both in its raw state and also during the process of manufacture. It can be stained the same as wood veneer and at the same cost, having approximately 80 per cent. of the strength and 85 to 90 per cent. of the weight of oak.

THE Hancock Consolidated Copper Co., Mr. John L. Harris, superintendent, whose mines are located at Hancock, Mich., has recently ordered from the Sullivan Machinery Co. of Chicago a hoisting engine to be used for sinking the principal shaft and for permanent service, after the shaft is completed to its final depth of 4,000 feet.

This hoist will be of the first motion, heavy duty, Corliss type, with engines 24-inch diameter by 48-inch stroke, and two loose drums, 8 ft. in diameter by 9 ft. long, driven by band friction clutches, and designed for hoisting in balance. The drums will be grooved for 1¼-in steel rope, and the maximum hoisting speed under full load will be 3,500 ft. per

The clutches and band brakes will be steam operated, with automatic compressed air substitution in case the steam pressure falls below a given point, owing to accident or for other reasons.

TWO drops of ammonia on a lump of sugar eaten immediately is considered a fair antidote for internal cyanide poisoning. This is usually the treatment when peroxide of hydrogen cannot be obtained promptly. In cases of external cyanide poisoning a warm bath containing bicarbonate of soda and common salt will allay the eruption.

In the cylinders of a compressed-air locomotive, only a low cold-test oil should be used. The oil should show a gravity of about 29, and a cold test of—5 deg. Fahrenheit.

CHIPPINGS.

COST OF PUMPING WITH THE AIR LIFT.

This question is usually asked without giving several items which largely determine the answer. Thus, coal at $2 is one thing, at $4 another. Again, some wells are nearby and in other plants the pipe investment is greater because of scattered wells. Speaking generally, the average cost per thousand gallons pumped depends on the size of plant and height of lift. In a 4,000,000-gal. plant, with a 50-ft. lift, it is about ⅓c. per 1,000 gal. In a larger plant, with a 35-ft. lift, with coal at $2, it is about 1½ mills. In another case, where the lift is 75 ft. and the capacity 1⅓ million gal., the cost is 1c. per 1,000 gal., coal costing $2. In a plant pumping 3,000,000 gal. 75 ft. high, the cost is 4.5c., and where the lift is 50 ft. 3.5c. In Pennsylvania, a plant giving 175 gal. per minute at 75-ft. lift, costs 1⅓c. per 1,000 gal. In a proposed municipal plant 100,000,000 gal. per 24 hours, 50-ft. lift, and with coal at $1.50 a ton, the cost figured 1 mill per 1,000 gal., including all fixed and operating expenses. In another case, involving the handling of about 15,000,000 gal, of water 30 ft. high every 24 hours, using compound condensing compressors, and with coal at $2 per ton, other figures being estimated on a very generous basis, the cost nets about $2.50 per 1,000,000 gal., or about 2½ mills per 1,000 gal. These figures cover fuel, oil, labor, sinking fund, interest and taxes.

In many cases the introduction of the air lift may be effected at little expense, often involving the purchase only of an air compressor, a receiver, and a small amount of pipe, but the following is estimated on a basis which will cover the greatest amount of expense likely to be incurred, with a view of showing particularly that the interest and depreciation charges under the most extreme conditions are not likely to develop into formidable figures. The following is a list of the complete equipment for an air lift plant to raise 1,500,000 gal. per 20 hours, or 1,250 gal. per minute. Total lift, 75 ft.: Air compressor, complete, ready for foundation and piping. Air receiver. Boiler, 85 h.p., with feed pumps, etc., bricked up and ready for use, including building and value of ground so occupied. Tank, 19,000 gal. capacity, including suitable timber framework to bring tank 75 ft. above water level. Two 12-in. wells, each 135 ft. deep, cased. Casing, 450 ft. 7⅝ in. light pipe. Air pipe, 500 ft. of 3-in., air pipe in wells. Air pipe, 1,000 ft. of 4-in. air line from receiver to wells. Water pipe, 1,250 ft. of 12 10 and 8-in. cast-iron distributing main, leaded joints, from tank to works, laid below frost (air line laid in same trench). All other pipe and fittings. Compressor, receiver and tank foundations, laid in cement. Special automatic governing mechanism. Total estimated cost of complete plant, ready to run, as above, $8,750. This is intended to include everything which may be considered as a legitimate expense in this connection. In many cases the buildings, boilers, tanks, wells, pipe lines, ground space, and other items do not represent a present expense, being already on the ground.

We may estimate the cost of operation as follows: Engineer, double shift, at $2.25 per day, $4.50, ⅕ time chargeable to pumping plant, per day, $0.90; Fireman, double shift, at $1.75 per day, $3.50, on the basis of one man required for each 250 h.p. of boiler for 85 h.p. per day, $1.19; fuel, 85 h.p., 20 hours, say 4¼ tons, at $2 per ton, per day, $8.50; oil, waste and sundries, say, 60 cents; interest on investment of $8,750 at 5 per cent., figuring eleven 25-day months, or 275 working days per year, per day, $1.91; deterioration, covering sinking fund, repairs, etc., providing for renewal of complete plant every ten years same basis as interest but 10 per cent., per day, $3.18; insurance and taxes at 1 per cent., as above, per day, 32 cents; total estimate cost of pumping 1,500,000 gal. per day, 75 ft. high, under the above conditions, $16.60. Cost of each 1,000 gal. ($16.60 ÷ 1,500) = $0.01107.—*The Engineering Record.*

TO one who has followed the recent developments in mining machinery it is evident that the air hammer rock drill marks as important a step in progress as any since the introduction of power-driven drills. The air hammer drill is cheap, wonderfully efficient, economical to operate and is adapted to a variety of uses. As a measure of utility, it can be said that nearly every one of the half doen or more manufacturers of these machines is working full capacity to meet the demand of the mining industry.

LIMITS TO LOSSES IN COMPRESSED AIR SERVICE

We hear certainly enough, and probably too much, of the power losses which inevitably accompany the employment of compressed air as a transmitting and operating medium. We certainly do not hear enough of, and do not sufficiently bear in mind, the fact that whatever these losses may be there is always a limit to them which can not well be exceeded. Steam losses seem to be without limit.

In the development of power by means of steam the coal-cost per horse-power hour in steam-operated apparatus in actual use ranges from below 2 lbs. to above 40 lbs. There is no loss in compressed air practice comparable with this. In the compression of air to, say, six atmospheres, a very common working pressure the power cost by adiabatic—the most costly—compression exceeds the cost by the ideal and practically impossible isothermal compression by only 32 per cent., and there is no discoverable way of making the cost of air compression any greater. The air compressors in use a score of years ago were crude and wasteful as compared with those which may be considered standard to-day. In the improvements which have been made in steam-driven air compressors the power savings effected have been much greater at the steam ends than at the air ends.

But it is rather in the employment of the air after compression that the limitation of losses most asserts itself. The unceasing condensation and disappearance of steam, beginning immediately upon leaving the boiler and continuing uninterruptedly after leaving belongs to steam alone; air has no corresponding or comparable loss. The volume of air delivered by the compressor decreases somewhat with its fall in temperature, but when normal temperature is reached shrinkage ceases and this loss ends. The water of condensation is another thing to be reckoned with in the use of steam, and also the delay and the steam-cost of heating up the steam-operated machine every time it is operated, with neither of which conditions does the air have anything to do. Compressed air seems to be unique among power transmitters in that it is always ready to do its full work and yet charges nothing for its time while standing waiting.

The beginning of the employment of compressed air for driving rock drills in mines and tunnels was enforced by other considerations than these, but mines and tunnels are not now the largest employers of compressed air. It is no wonder that we find it making its way for work in the open, that many quarries are operated by it exclusively, that such undertakings as the enormous excavations in New York for the new stations of the Pennsylvania and the New York Central Railroads should each depend upon the air compressor to do the most of the work. Most of the air in these cases is not transmitted more than the length of half a dozen city blocks; where the distances are greater the advantages of air power transmission becomes more pronounced, and so it is entirely in line with the most advanced engineering practice that air compressors are finding employment upon the Panama Canal. When we hear of many more compressors being installed upon the job we may find therein increased encouragement to hope for the ultimate successful completion of the work.

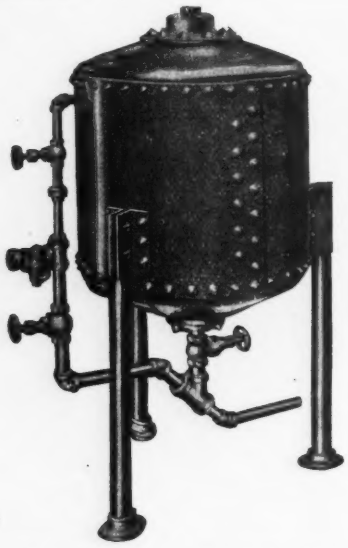
Notwithstanding the many great engineering works in progress and the number of air compressors employed upon them, there seems to be little danger of their working themselves out of a job. Their work grows upon them and one thing follows another. Two of the largest of the 100 compressors now employed upon railroad and tunnel work in or immediately in touch with New York City were previously used on the excavation work for the works, another in open-air operation.—*Cassier's Magazine.*

Compressed air locomotives, which in the past few years have come into extensive use for mine haulage, work under pressures ranging from 500 to 2,000 lbs. per square inch. The pressure is determined mainly by the size of the locomotive permitted by the dimensions of the tunnels and curves. In tunnels of good size the large reservoirs required by low pressure engines are permissible, but where only small reservoirs can be used it is necessary in order to carry the supply of power required to compress the air to a higher degree in the steel tubes (bottles, as they are sometimes called), which are made of such a strength as to safely carry the pressure.—*Iron Age.*

COMPARISON BETWEEN THE HIGH PRESSURE SAND BLAST AND THE LOW PRESSURE MACHINES

The difference between high pressure sand blast and low pressure machines, says the *Boiler Maker,* depends upon a principle which is distinctly radical.

The principle on which, up to date, the different blasts have been working was, to use low pressure (15 to 30 lbs.) and a large nozzle. These machines use anywhere from 60 to 490 cu. ft. of free air per minute, with 3/8-in. to 7/8-in. nozzles.



It will be seen from the following that in order to work such blasts economically, it is necessary to install, in addition to the regular shop compressor (carrying from 80 to 100 lbs. air pressure), for these blasts an extra compressor working under low pressure. The idea of taking the air from the regular shop system and reducing it by a reducing valve to 15 or 30 lbs. is out of the question, as the power lost by this method would mean throwing money away.

The fact that a cubic foot of air at 80-lbs. pressure is equal to about 3 cu. ft. at 15 lbs. leads most people astray, but if they consider that by taking the air for the sand blast from the shop system they have to compress the amount of free air per minute used by the blast at first to the shop pressure of 80 to 100 lbs., while, by having an extra compressor for the blast, it is only necessary to compress the certain amount of free air per minute used by the blast, to 15 or 30 lbs., they will realize the saving of power.

The principle on which the Farnham sand blasts work is to use a small nozzle and a high pressure and the amount of cubic feet of free air used by this blast, at this high pressure, is considerably less than the present machines use with the low pressure; in other words, the blast is worked just as economically by taking the air directly from the shop system as it is by having an extra compressor. In the latter case the great advantage is, that much smaller compressors can be used.

By using a small nozzle and high pressure, a smaller area (at a time) is covered than by the low pressure machines, but the area is covered much quicker and the total time consumed to cover a given area is the same for both machines, the high pressure machines having the advantage of doing much better work.

This blast has been used for the past three years in the United States and England with great success on exterior work, such as cleaning bridges, houses, etc., but recent tests at different railroad shops on castings, structural iron work, etc., have proven so successful, that it was decided to place the device on the market for use in foundry and machine shops.

The construction of the blast is very simple; in fact, almost everything is shown on the cut, the only thing not shown is an injector which is placed in the Y beneath the tank and directly in the center and underneath the sand discharge pipe.

The pipe leading into the top of the tank does not extend into the sand; it is simply there for the purpose of avoiding a vacuum or a back pressure from the injector when the tank is discharging the sand. On all present blasts this pipe extends through the sand into the mouth of the discharge and any moisture in the air is apt to clog up the sand at this point and prevent it from flowing freely. The sand which falls by gravity from the tank is also forced down by the air pressure on top and the suction created at the bottom by the injector.

The point, that all wearing parts are standard pipe fittings, should be appreciated by the customer. No special castings are employed and the only wearing part is the elbow at the bottom, which can be easily, quickly and cheaply replaced.

The hose, which is the only other wearing part, is ¾-in. diameter, and as other blasts employ considerably larger hose, the cost of maintenance of this machine will be lower.

The blast has a drain cock at the point where connection with the air system is made and the water, which will collect in the piping while the blast is idle, is to be blown off first before the blast is started.

Another point worth mentioning is, that the small opening in the injector will prevent an excessive air consumption when the nozzle wears out, the machine simply can not use more air than will pass through the small injector opening.

SULPHUR deposits of considerable value occur in the State of Louisiana. Great difficulty was at first experienced in dealing with these deposits, which occur at a depth of between 600 ft. and 800 ft. below the surface, by reason of the fact that the over-laying strata contained quicksand. The beds have been ascertained to be between 100 ft. and 200 ft. thick and extend for many miles underground. They are now being mined by means of steam and compressed air. Borings are driven into the stratum of sulphur, and a steam pipe leads down to the bottom of the bore. Steam is then forced down the pipe, and the melted sulphur is brought to the surface by a compressed air lift-pump system. At the surface it is discharged into large concrete-faced shallow vats or pools, where it is allowed to solidify, after which it is broken up and shipped to the refinery or direct to the market.

TESTS of a pneumatic hammer, states the *Industrial World*, reveal the fact that a very slight error of design or adjustment of the value may affect the efficiency of the tool to a very marked degree. With a certain hammer, giving 936 blows per minute, the piston had a velocity of impact of 38.56 feet per second at the end of the forward stroke. A slight improvement in the valve increased the number of blows to 1040 per minute, while the velocity of impact at the end of the forward stroke was 44.65 feet per second, resulting, of course, in a much more effective blow.

THE increasing use of compressed air in manufacturing and power plants, car barns, etc., has given quite an impetus to the manufacture of electrically driven air compressors which are self-contained and conveniently taken to the place where the compressed air is utilized. In drilling, riveting and chipping compressed air tools can be more advantageously employed than purely manual or mechanically operated devices. In electric railroad car barns or at steam railroad terminals compressed air is convenient and effectual in cleaning out dirt and dust. In power houses and substations it offers many advantages in blowing out dust from generator coils, field magnets and commutators. In automobile garages it is especially useful for inflating tires, cleaning dust from cushions, running gear, etc. The simplicity, flexibility, cleanliness and reliability of air as a source of power for a great many different purposes is coming to be better recognized.—*Iron Age.*

COMPRESSED air differs from electricity, especially in the fact that electrical friction losses cannot be regained, while corresponding losses with compressed air may be eliminated. The moderate fall in pressure in the air due to friction augments a loss of transmission. "If the air were at 80 lbs. gauge or 95 lbs. absolute upon enterting the pipe, and 70 lbs. gauge or 85 lbs. absolute at the other end, there would be a loss of a little more than 10 per cent. in absolute pressure, but at the same time there would be an increase of volume of 11 per cent. to compensate for this loss of pressure, and the loss of available power would be less than 3 per cent."

MANY experienced drill sharpeners gauge the bits by eye only. All drill sharpeners, no matter how expert, should be made to use a gauge in sharpening the steel. There is nothing more aggravating than wasting time in a hunt for a drill to follow one with a small bit. Many foremen are extremely careless in regard to the steel which they furnish to their miners.

A COTTON-PICKING machine has been invented by A. G. Kinyon, road foreman of the Southern Railway, that will straddle a row of cotton, and as the machine is drawn along it will draw portions of the cotton into a vacuum chamber. This chamber is connected with a suction apparatus of sufficient power to draw the staple from the boll, then through pipes into a box arrangement back of the machine.

The compressed air which operates the machine is generated by the wheels of the machine as it is drawn along the cotton rows.

Full specifications regarding any of these patents may be obtained by sending five cents to the Commissioner of Patents, Washington, D. C. (Stamps will not be accepted.)

850,180. PNEUMATIC SPRING FOR VEHICLES. VACLAV H. PODSTATA and FRANK M. PREUCIL, Chicago, Ill. Filed March 12, 1906. Serial No. 305,444.

850,208. AIR-COMPRESSOR. EINAR J. BRING, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. Filed May 7, 1904. Serial No. 206,913.

AIR OR OTHER GASES. EDWARD W. LLOYD and WILLIAM H. SODEAU, Newcastle-upon-Tyne, England, assignors to W. G. Armstrong, Whitworth & Co., Limited, Newcastle-upon-Tyne, England. Filed June 22, 1906. Serial No. 322,935.

850,329. ELECTRIC AND PNEUMATIC GOVERNOR. HARRY W. YOUNG, Philadelphia, Pa., assignor to John E. Reyburn, Philadelphia, Pa. Filed Jan. 22, 1906. Serial No. 297,147.

850,366. PNEUMATICALLY-OPERATED MUSICAL INSTRUMENT. JOHN J. HEALY, Monroe, N. Y., assignor of one-half to Solomon F. Hess, Rochester, N. Y. Filed Dec. 9, 1904. Serial No. 236,251.

850,564. AIR-BRAKE MECHANISM. JOHN J. COIT, Venice, Cal. Filed Nov. 15, 1906. Serial No. 343,560.

850,387. PNEUMATIC SPRING. ALONZO C. MATHER, Chicago, Ill. Filed Aug. 22, 1906. Serial No. 331,572.

850,592. PNEUMATIC VIBRATOR OR HAMMER. WILFRED LEWIS, Philadelphia, Pa., assignor to The Tabor Manufacturing Company, Camden, N. J., a Corporation of New Jersey. Filed Oct. 5, 1906. Serial No. 337,502.

850,327. PNEUMATIC TREAD FOR BOOTS AND SHOES. ISIDOR TAUBER, Vienna, Austria-Hungary. Filed Nov. 16, 1906. Serial No. 343,707.

850,639. PNEUMATIC DEVICE FOR DRAWING OUT GRAINS AND SIMILAR GOODS. PAUL GEBHARDT and CARL GEBHARDT, Stralau, near Berlin, Germany. Filed Sept. 24, 1906. Serial No. 336,029.

850,635. PNEUMATIC VALVE FOR MUSICAL INSTRUMENTS. AUGUST W. FLEGEL, Cranford, N. J., assignor to The Aeolian Company, New York, N. Y., a Corporation of Connecticut. Filed Oct. 18, 1906. Serial No. 339,439.

850,674. COMPRESSED-AIR SPRAYER. CLARENCE W. PARKS and AGNES E. PARKS, Lowell, Mich. Filed Sept. 9, 1905. Serial No. 277,759.

850,700. PNEUMATIC COTTON-HARVESTER. JAMES E. WORSWICK, Montgomery, Ala., assignor of one-half to George P. Haardt, Montgomery, Ala. Filed May 19, 1906. Serial No. 317,781.

850,706. MEANS FOR INFLATING PNEUMATIC TIRES. ALBERT A. WITHERS, Balaclava, Victoria, Australia. Filed Aug. 28, 1905. Serial No. 276,178.

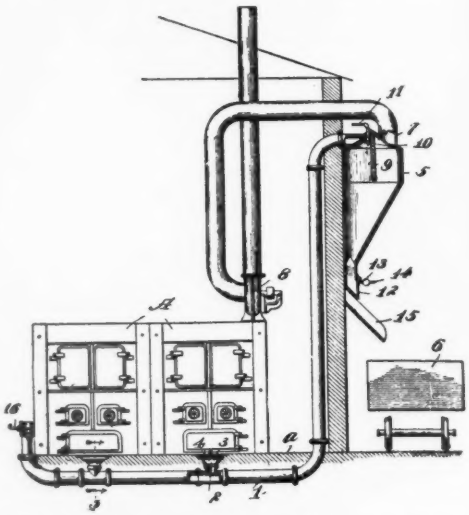
849,599. AUTOMATIC EMERGENCY-BRAKE. WILLIAM COOPER, Georgetown, Colo. Filed Dec. 18, 1906. Serial No. 348,406.

850,909. NOZZLE FOR PNEUMATIC CARPET-CLEANING APPARATUS. RALPH F. DISERENS, Bradford, Pa. Filed July 5, 1906. Serial No. 324,733.

850,956. PNEUMATIC TIRE. GEORGE L. McQUIGG, Flint, Mich. Filed Oct. 11, 1906. Serial No. 338,436.

850,999. DISK DRILL. SPENCER E. DAVIS, Minneapolis, and THOMAS BRENNAN, JR., St. Louis Park, Minn. Filed July 23, 1906. Serial No. 327,261.

851,054. PNEUMATIC CONVEYER. EDWIN M. BASSLER, Chicago, Ill., assignor to The Economic Engineering & Construction Company, Chicago, Ill., a Corporation of Illinois. Filed Aug. 4, 1905. Renewed Sept. 28, 1906. Serial No. 336,597.



Claim.—In a conveyor, the combination of a conduit provided with an admission opening or openings, a receptacle into which said conduit discharges, said receptacle being provided with an air-discharge opening, means to create a current of air through said conduit and means to wet the material delivered into said receptacle from said conduit.

851,334. DIAPHRAGM-PUMP. GEORGE J. ALTHAM, Swansea, Mass., assignor to Aero and Marine Motor Company, Boston, Mass., a Corporation of Massachusetts. Filed July 17, 1905. Serial No. 269,914.

851,338. SAFETY-CLUTCH FOR AIR-BRAKE ANGLE-COCKS. SIDNEY J. BARNHOUSE, Alexandria, Va., assignor of one-third to John G. Bayne, Alexandria, Va. Filed Feb. 8, 1905. Serial No. 244,817.

851,362. SIGNAL APPARATUS. ERNEST DE MERINDOL MALAN, London, England. Filed Dec. 5, 1906. Serial No. 346,433.

851,364. CENTRIFUGAL PUMP. ELOF MEDEN, Trenton, N. J., assignor to The Jeanesville Iron Works Company, Hazleton, Pa., a Corporation of Pennsylvania. Filed April 5, 1905. Serial No. 253,979.

851,393. PNEUMATIC WHEEL-SUPPORT. GEORGE W. BELL, Liverpool, England. Filed Jan. 31, 1906. Serial No. 298,759.

851,472. PNEUMATIC MOTOR. PHILIP WUEST, JR., Philadelphia, Pa., assignor to The Auto-Manual Piano Action Company, Philadelphia, Pa., a Corporation of New Jersey. Filed Sept. 19, 1906. Serial No. 335,167.

851,556. DRIVING MECHANISM FOR AIR-COMPRESSORS. BRYAN OBEAR, St. Louis, Mo., assignor to Montague Compressed Air Company, St. Louis, Mo., a Corporation of Missouri. Filed Feb. 1, 1905. Serial No. 243,711.

851,624. PNEUMATIC TOOL. CHARLES H. HAESELER, New York, N. Y., assignor to Ingersoll-Rand Company, a Corporation of New Jersey. Filed Feb. 21, 1907. Serial No. 358,605.

851,754. CARRIER-SEPARATOR FOR PNEUMATIC-TUBE APPARATUS. Chester S. Jennings, Brookline, Mass., assignor to Lamson Consolidated Store Service Company, Newark, N. J., a Corporation of New Jersey. Filed June 21, 1906. Serial No. 322,791.

851,766. AUTOMATIC BRAKE. Johann J. Muller, Zurich, Switzerland, assignor to Henry Baer and Company, Zurich, Switzerland. Filed Sept. 22, 1906. Serial No. 335,792.

851,237. PNEUMATIC STACKER. Ole Holden, Britton, S. D. Filed May 31, 1905. Serial No. 263,173.

851,316. AUTOMATIC AIR-SIGNAL, AIR-BRAKE, AND STEAM COUPLING. Herman C. Priebe, Blue Island, Ill. Filed July 31, 1906. Serial No. 328,552.

851,818. AIR-BRAKE SYSTEM AND ENGINEER'S VALVE. George Macloskie, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. Filed Nov. 9, 1905. Serial No. 286,513.

851,874. AUTOMATIC CAR-BRAKE. Charles Fero, Jr., Bay City, Mich., assignor of one-third to Frank Thompson, Bay City, Mich. Filed Oct. 8, 1906. Serial No. 338,041.

852,007. AIR-BRAKE APPARATUS. Robert J. Wilson, Pittsburg, Pa. Filed Nov. 16, 1905. Serial No. 287,664.

852,046. DRILLING-MACHINE. Erik Westberg, Geoff, N. D. Filed July 7, 1906. Serial No. 325,125.

852,108. AIR-BRAKE SYSTEM. Daniel M. Daley, West Seneca, N. Y. Filed May 29, 1906. Serial No. 319,369.

852,109. DRILL. Dean B. Edwards, Wauchope, Saskatchewan, Canada. Filed Aug. 3, 1906. Serial No. 329,063.

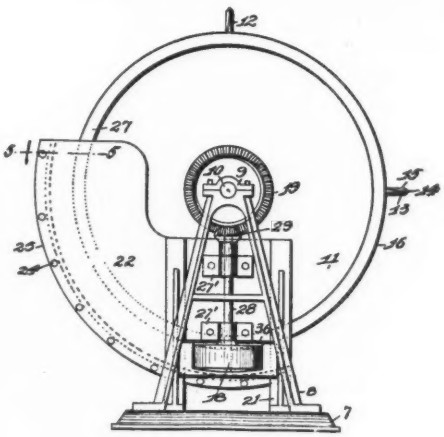
852,117. PNEUMATIC APPLIANCE FOR CARS. George H. Hollingsworth, Belmont, Mass., assignor to Consolidated Car Fender Company, Providence, R. I., a Corporation of Rhode Island. Filed Feb. 12, 1907. Serial No. 357,084.

852,157. SAFETY-VALVE FOR AIR-BRAKES. Thomas Behan, Alliquippa, Pa. Filed March 20, 1906. Serial No. 307,115.

852,161. PNEUMATIC PLAYER FOR MUSICAL INSTRUMENTS. George P. Brand, New York, N. Y. Filed Feb. 23, 1905. Serial No. 246,864.

852,541. AIR-COMPRESSOR. Reginald A. Cousans and Louis B. Cousans, Lincoln, England. Filed Nov. 30, 1903. Serial No. 183,305.

852,749. ROTARY AIR-COMPRESSOR. Gustav C. Vollmer, St. Louis, Mo. Filed Jan. 15, 1906. Serial No. 296,068.



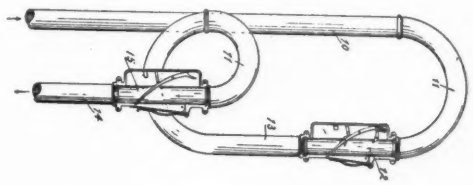
Claim.—A rotary air compressor comprising a revolving-member mounted upon a shaft, a casing forming a compression chamber through which the revolving-member operates, said casing covering a portion of the revolving-member, a cut-off located at the bottom of the revolving-member and operated by the revolving-member, said cut-off having its upper casing concave and its lower face convex to correspond with the formation of the casing and the periphery of the revolving-member, and provided with a recess for the admission of the revolving-member, substantially as specified.

852,817. AIR-COMPRESSOR. Reinold Berrenberg and Alonzo S. Drisko, Boston, Mass. Filed March 16, 1905. Serial No. 250,458.

852,889. PISTON FOR AIR-COMPRESSORS. Robert Miehle, Chicago, Ill. Filed July 24, 1905. Serial No. 270,917.

852,899. AIR-BRUSH. Jens A. Paasche, Chicago, Ill. Filed Sept. 8, 1906. Serial No. 333,743.

852,913. PNEUMATIC-DESPATCH APPARATUS. Fred R. Taisey, Indianapolis, Ind., assignor to The Lamson Consolidated Store Service Company, Boston, Mass., a Corporation of New Jersey. Filed May 24, 1906. Serial No. 318,474.

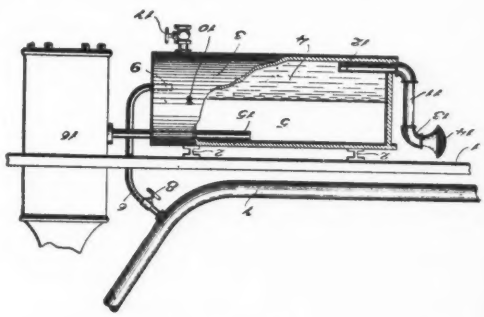


Claim.—A terminal in a pneumatic despatch apparatus having a passage-way therethrough and a discharge opening, a director projecting into the passage-way therein in a position when locked to deflect a carrier through the discharge opening, and means pivoted on the deflecting end of said director which projects into the passage-way and operable by a carrier for locking the director.

852,924. PRESSURE-REGULATING VALVE. Richard E. Bruns, Chicago, Ill. Filed July 10, 1905. Serial No. 268,935.

852,976. AUTOMATIC REGULATOR FOR AIR AND GAS COMPRESSORS. Fred E. Norton, Youngstown, Ohio. Filed April 11, 1906. Serial No. 311,033.

853,137. AIR-CLEANER FOR AIR-BRAKE SYSTEMS. Roston S. Wallace, Birmingham, Ala. Filed Nov. 3, 1906. Serial No. 341,933.



Claim.—An air cleaner for air brake systems comprising a cylindrical reservoir containing a body of water, an air chamber above the water line, an intake air pipe terminating at a point below the water line and extending above the water line outside the reservoir, and provided with a screen at its intake end, an outlet air pipe extending into the air chamber and connected to the pump for supplying air to the brake system.

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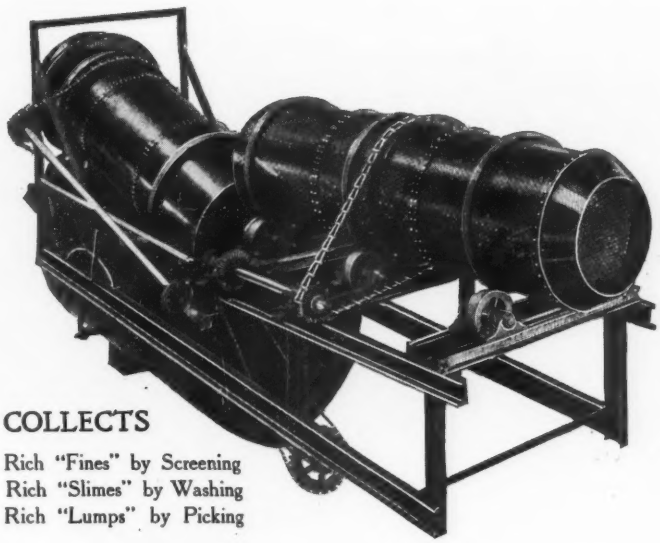

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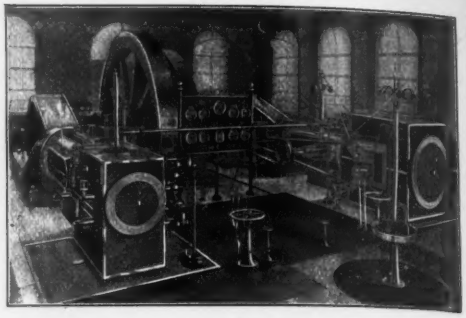

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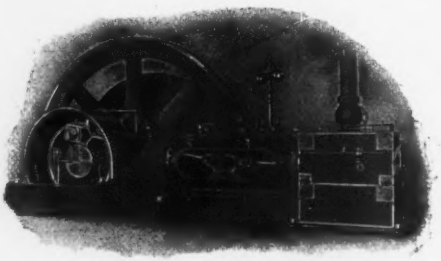

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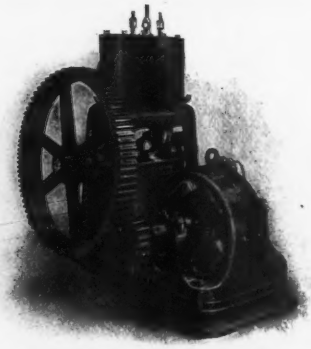

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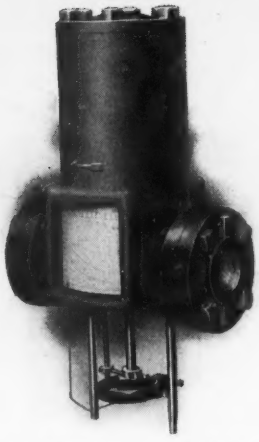

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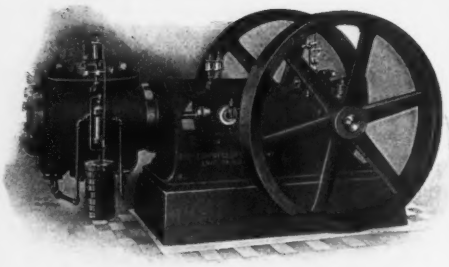

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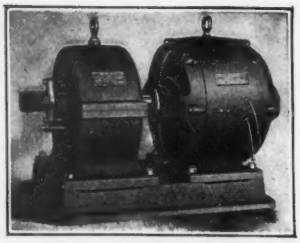

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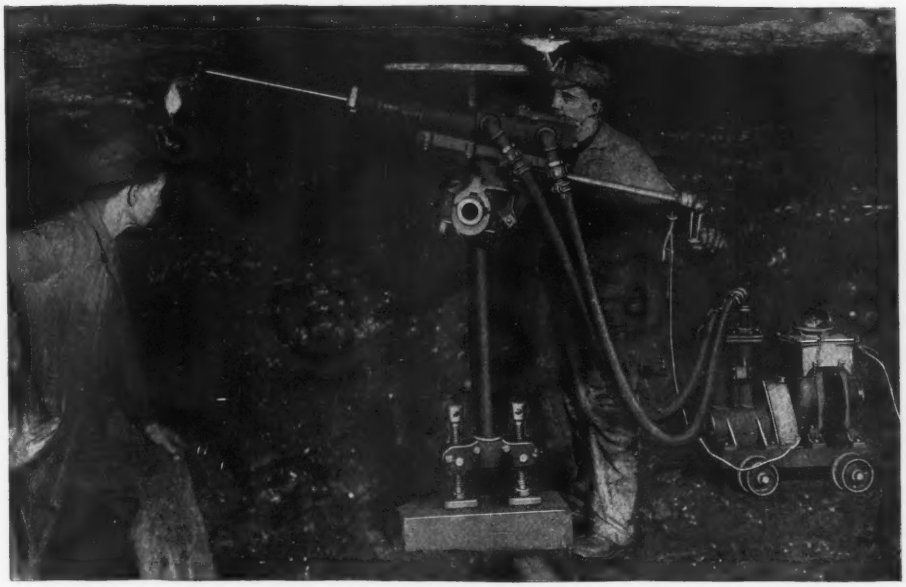

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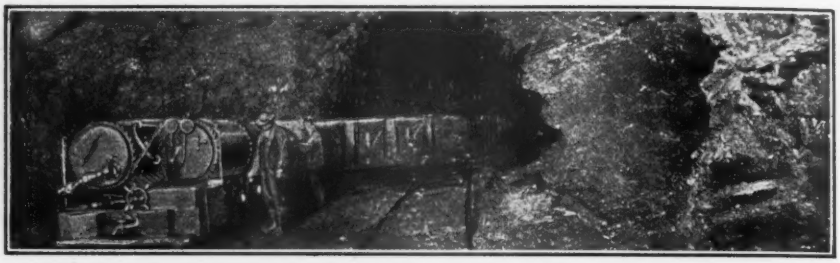

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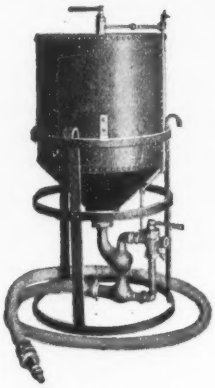

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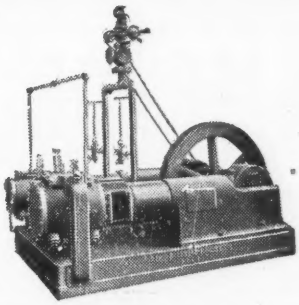

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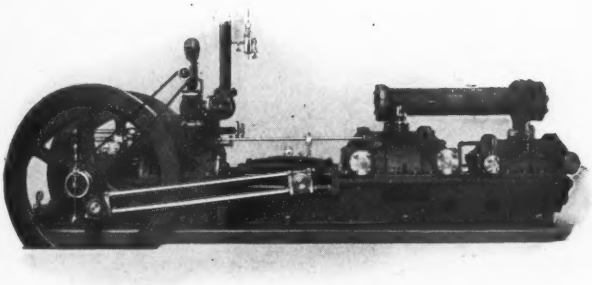

The Sullivan two-stage Straight Line Compressors are well known for their economical performance under trying conditions.

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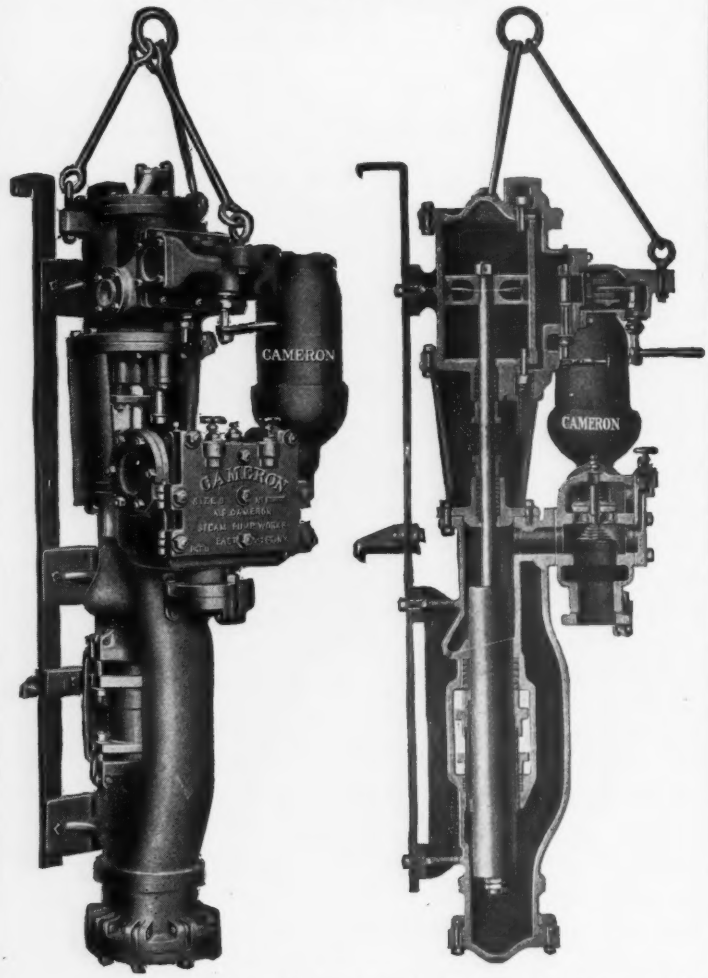

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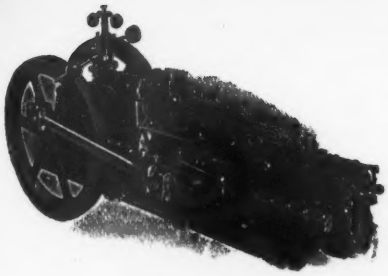

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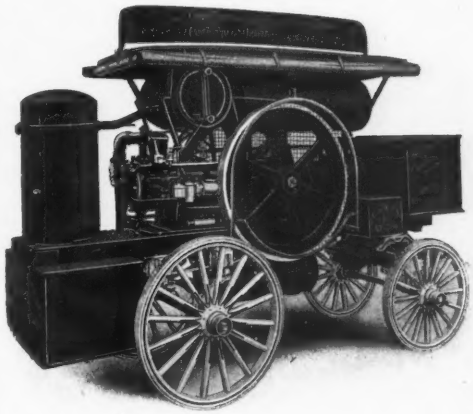

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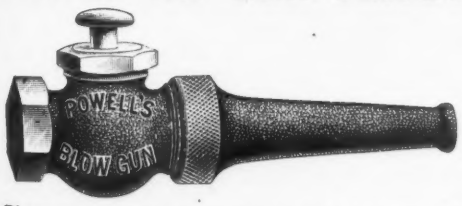

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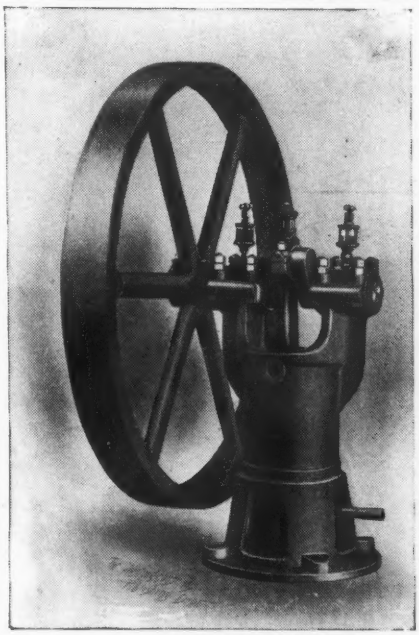

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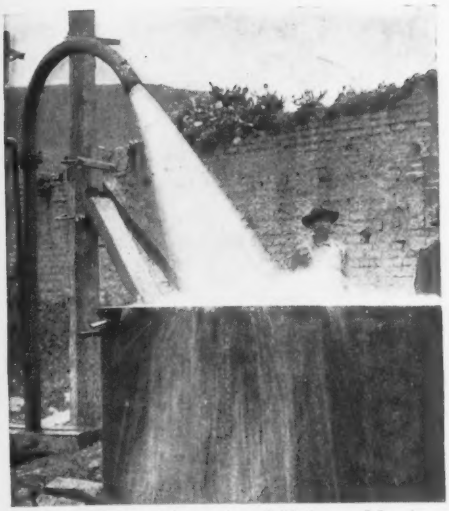

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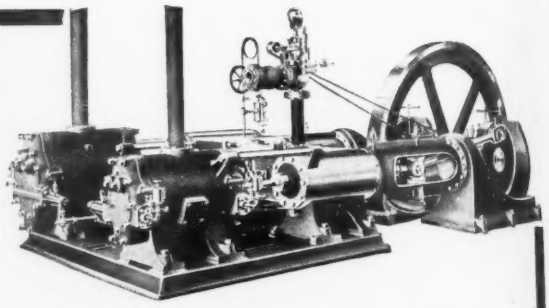

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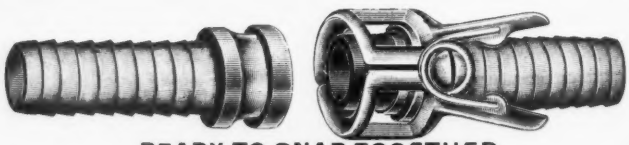

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